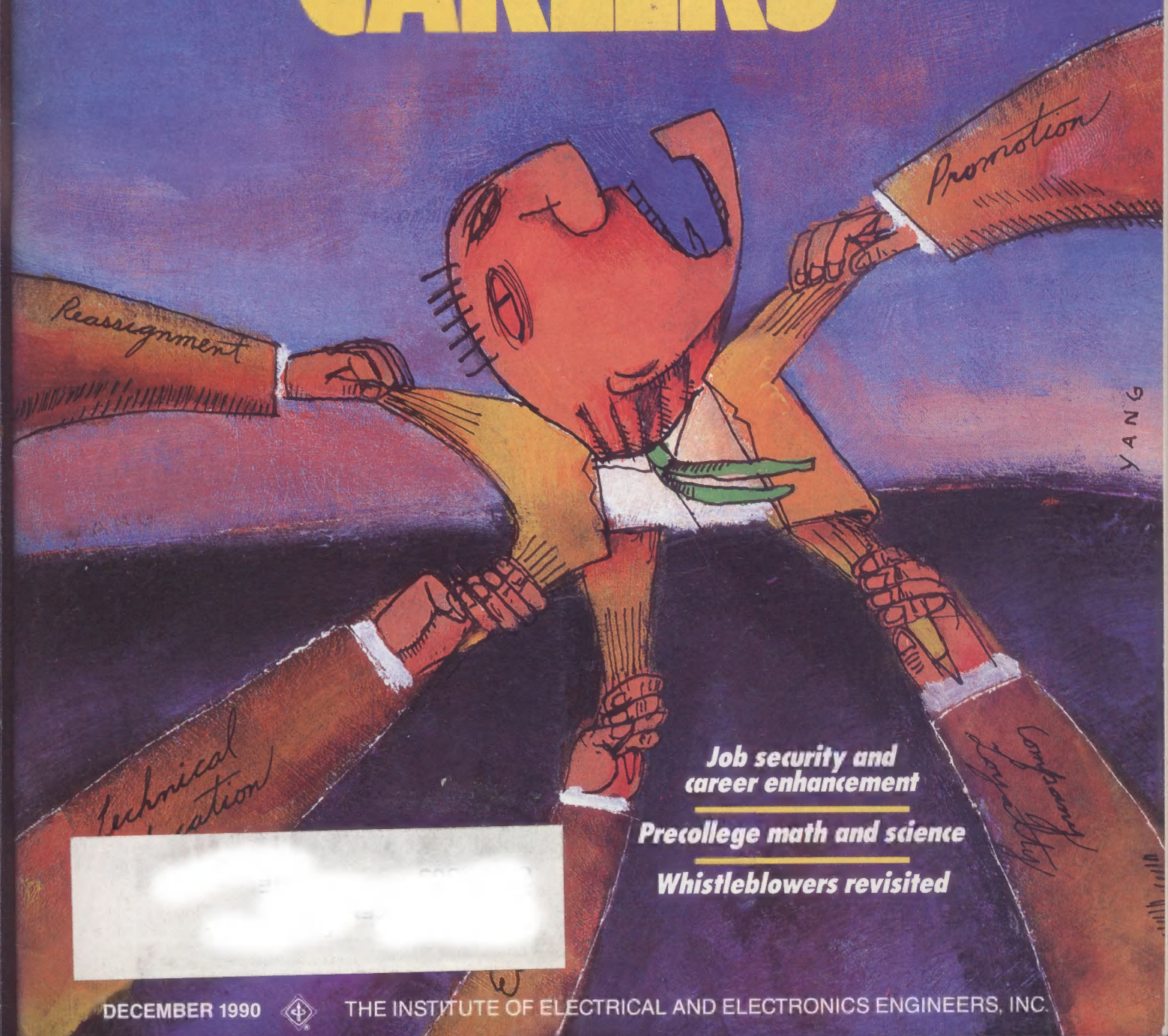
ROBOTS IN JAPAN ■ AUTOMOTIVE ELECTRONICS '91 ■ SIEMENS RESTRUCTURES

IEEE
SPECTRUM

ENGINEERING CAREERS



Job security and career enhancement

Precollege math and science

Whistleblowers revisited

DECEMBER 1990 THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

To open the window of opportunity in solving DSP and Image problems, open our window first.

HYPERSIGNAL-WINDOWS™

Comprehensive Advanced Signal Processing Environment for Engineers and Scientists.

Hyperception

For more information, including catalog, contact:

Hyperception, Inc.
9550 Skillman LB 125
Dallas, TX 75243

Phone: 214-343-8525
FAX: 214-343-2457

International Representatives

GERMANY - Electronic Tools, phone: (02102) 841013, TLX 1631 + BTX 02102841013 1 +, fax: (02102) 841000 * UK, IRELAND - Loughborough Sound Images, LTD., phone: (0509) 231843, TLX 341409 LUFBRAG. fax: (0509) 262433 * FINLAND - ITT, phone: (90) 739 100, TLX 121450 MultiKomponent, fax: (90) 712414 * FRANCE - BORES Technical Sales, phone: CC44 (0483) 740136 * DENMARK - Assentoft Electronics, phone: (86) 16 29 26, fax: (86) 16 20 12 * ISRAEL - IES Ltd., phone: (03) 7526333, fax: (03) 7510927 * TAIWAN, ROC - EXARTECH International Corp., phone: 5372201 ~ 3, fax: (02) 5422689, TLX:26173 EXARTECH

Circle No. 4

We're More Than Just Temperature™

SATISFYING THE CUSTOMER IS OUR #1 PRIORITY.

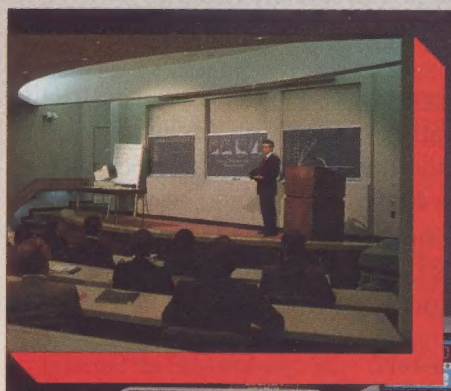
We control the quality of all products manufactured at our facilities. Our production methods are constantly refined and reviewed so you receive the best product possible. Items produced elsewhere are subject to an equally scrutinizing test procedure. We accept nothing but the finest—and that's what our customers have learned to expect!

CHALLENGE US WITH YOUR REQUIREMENTS!

OMEGA's Custom Engineering and Design department provides service and products beyond our handbooks—no matter how small or large, straightforward or complicated the assignment. So, if you don't see exactly what you need in our sales literature, just call—you'll be pleasantly surprised! FAX your custom requirements to: 203-359-7890 or call 203-359-1660.

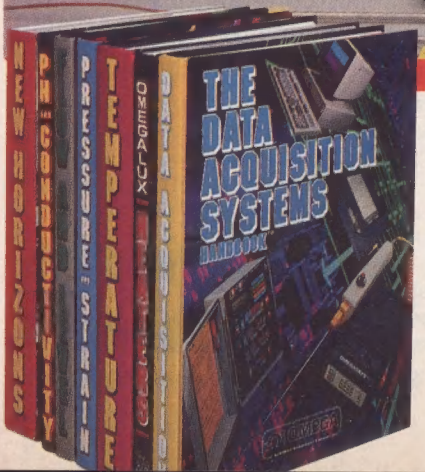
STATE-OF-THE-ART FACILITIES.

OMEGA is headquartered in Stamford, CT, in nearly 500,000 square feet of high-tech office space on 32 acres. Our fully-equipped conference center includes a spacious 140-seat auditorium. We offer training seminars conducted by our own expert engineering staff. An additional manufacturing facility is located in Bridgeport, NJ.



IF IT MEASURES/CONTROLS A PROCESS LOOK TO OMEGA® !

OMEGA markets over 20,000 products for Temperature and Humidity; Pressure, Strain and Force; Load; Displacement; pH and Conductivity; Flow and Level; and Data Acquisition; plus, Electric Heaters.



NEW! FREE! NOW WITH HARDCOVERS!

With over 4000 full-color pages, featuring more than 20,000 products with fast off-the-shelf delivery, the seven volume set is packed with the finest process measurement and control devices. All prices are listed. Our newest volume, the Instrumentation and Reference Yearbook, contains a wealth of valuable technical data and exciting, brand new products. And, remarkably, the entire set is FREE for qualified professionals!

For FREE Handbook Request Form Circle Reader Service Number 3

In A Hurry for Your FREE Handbooks?

DIAL (203) 359-7874 (203) 359-RUSH

We're More Than Just Temperature™

OMEGA®

An OMEGA Technologies Company

One Omega Drive, Box 4047, Stamford, CT 06907
Telex 996404 Cable OMEGA FAX (203) 359-7700

Airline passengers will soon view movies on personal video screens directly in front of them, make phone calls from their seats, and shop via credit card for in-flight merchandise from shopping channels. These and other features, including satellite-delivered stock market reports and up-to-the-minute news and sports highlights, are part of a new cabin communications and passenger entertainment system that will bring new levels of comfort and convenience to air travel. A team of Hughes Aircraft Company, Sony Trans Com Inc., and Hughes-subsidiary Avicom International is developing the system for the new Airbus A330 and A340 jetliners.

A self-contained plasma source will help prolong the life of satellites in space. The source, part of the Flight Model Discharge System (FMDS), developed and built by Hughes for the U.S. Air Force, produces a dilute low-energy plasma cloud near the spacecraft's surface. This cloud effectively "grounds" the vehicle by forming a conductive bridge that electrically couples the vehicle's outer surfaces to each other and to the plasma of space. Without FMDS, electrical charges from ionized gases could build up on the spacecraft, causing arcing that could damage delicate electronic equipment.

An improved flow of information between air defense command and control centers and surface-to-air missile systems will be one result of a new state-of-the-art communications link being designed by Hughes. The link, called the Intelligent Interface Processor, will provide the signal interface between AN/TSQ-73 surface-to-air missile control systems and fixed NATO Air Defense Ground Environment sites in West Germany, Italy, Belgium, and the Netherlands. With the new system, NATO commanders will be able to allocate targets to be engaged by missile batteries and still retain autonomy. Commanders will also be able to exchange target and status information currently available only through voice communications.

U.S. Military aircraft crews will now be protected against laser threats. Together with the U.S. Army, Hughes Danbury Optical Systems, a Hughes subsidiary, has developed a warning system for U.S. helicopter crews subjected to laser threats. The AN/AVR-2 Laser Detecting Set (LDS) detects, identifies and characterizes optical signals 360-degrees around the aircraft. Interfacing with a Radar Signal Detection Set, the system also functions as an integrated radar and laser warning receiver system. The Army and Marine Corps have successfully completed testing and initiated production of this laser detecting system, which will soon be standard equipment on their combat helicopters.

Three-quarters of a billion dollars are on the way. And in 1990, Hughes Aircraft Company's Ground Systems Group is anticipating many more new contracts, in Air Traffic Control (ATC), Air Defense, and the commerical sector. These new programs have created excellent career opportunities for experienced and motivated individuals in systems engineering, software engineering, and test engineering. Appropriate background for work in the defense and intelligence communities is preferred in some positions. For immediate consideration, please send your resume to Hughes Aircraft Company, Ground Systems Group, Dept. 1343-T, PO Box 4275, Fullerton, CA 91634. Equal Opportunity Employer. Proof of U.S. citizenship may be required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES

Subsidiary of GM Hughes Electronics

NEWSLOG

OCT 8: Four U.S. utilities said they will have their uranium enriched by a Soviet nuclear fuel processing venture at the **Ural Electrochemical Integrated Plant** in Sverdlovsk, in a US $250 million deal. The four are **Yankee Atomic Electric Co.** in Massachusetts, **Vermont Yankee Nuclear Power Corp.**, **Maine Yankee Atomic Power Co.**, and **New Hampshire Yankee**. New technology enables the Soviet plant to process the fuel with only a fraction of the energy used in U.S. plants.

OCT 9: Fourteen computer companies—including **IBM**, **Intel**, **NCR**, **Chips and Technologies**, and **Olivetti**—said they had formed a group to push for the adoption of a single computer bus standard. The goal is to expand the use of IBM's Micro Channel by providing PC makers with data on its architecture.

OCT 9: **Motorola Inc.** said it settled a patent dispute with Tokyo's **Hitachi Ltd.** that nearly forced the Schaumburg, Ill., company to stop selling its flagship 68030 computer chip. The two companies agreed to drop all charges made in a series of suits and countersuits launched by Motorola in 1989.

OCT 10: Over a dozen software firms said they had formed an industry self-policing group, the **Software Business Practices Council**, to reform "widespread, misleading and sometimes unethical marketing and accounting practices." Participants include **Lotus Development**, **Interleaf**, **Ashton-Tate**, and **Sybase**. Under council proposals, companies would tighten accounting procedures, avoid practices like channel stuffing, and refrain from announcing products before they have been shown to be technically feasible.

OCT 11: The **Federal Communications Commission,** Washington, D.C., adopted rules to give more channels and more power to "wireless cable" companies that use microwaves to broadcast programs currently to 300 000 subscribers in 50 cities. The changes would give these companies greater access to frequencies now used by schools and universities for instructional services and make it easier for them to increase the power of their signals.

OCT 14: In the largest award ever in a patent infringement case, a Federal judge ruled that **Eastman Kodak Co.**, Rochester, N.Y., must pay **Polaroid Corp.**, Cambridge, Mass., US $909.4 million for infringing seven of Polaroid's patents for instant photography. Polaroid had sought US $12 billion in damages.

OCT 16: Effectively taking the U.S. government out of the production of plutonium for nuclear bombs, Energy Secretary James D. Watkins said his department would not reopen **Plutonium-Uranium Extraction (Purex)**, near Richland, Wash. The plant, whose job for 33 years was to dissolve the spent fuel from nuclear reactors, was shut down in 1988 for safety reasons but was to have reopened next March. Community and environmental groups had sued to keep it shut.

OCT 17: **AT&T Co.** and Japan's **Kokusai Denshin Denwa** announced plans to link their two countries in 1996 with a radically new high-capacity undersea cable that could carry 600 000 simultaneous conversations, compared with 40 000 for cables laid in recent years. The cable exploits novel optical signal amplifiers.

OCT 20: The German Government informed Soviet officials that it will shut down five Soviet-built nuclear power reactors in the former East Germany by mid-December because they are unsafe and too expensive to adapt. Officials at the **Nuclear Energy Agency** in Paris, France, said the German decision would increase pressure to close at least 26 similar reactors in Eastern Europe and the USSR.

OCT 24: The **Superconducting Super Collider Laboratory**, Dallas, said it has awarded a US $200 million contract to **General Dynamics Corp.**, St. Louis, Mo., and **Westinghouse Electric Corp.**, Pittsburgh, to complete the design and begin high-volume manufacturing of superconducting magnets that will be used by the **U.S. Department of Energy**.

OCT 25: Combining cellular radio and computer technology, **Motorola Inc.**, Schaumburg, Ill., said it has developed a system that will allow office computers to communicate without wired links via microwave radio signals. The system should slash the costs of computer networks because it uses higher radio frequencies and signal-processing ICs that reduce equipment size and cost.

OCT 25: **Philips NV**, Eindhoven, the Netherlands, said it would eliminate 35 000–45 000 jobs, or 12–16 percent of its work force, by the end of next year. Philips said all areas of the company would be affected in a bid to restore the company's flagging profitability.

OCT 29: Scientists, academic researchers, and business executives at a three-day meeting in Seattle, Wash., on whether the U.S. government should foster high-technology development, reported a growing consensus that an **optical-fiber network to carry voice and data for business and video for home entertainment** would revitalize the U.S. microelectronics industry. Just two days earlier, Congress failed to pass a bill to provide a half-billion dollars for R&D to build a high-speed network linking the U.S. supercomputer centers.

NOV 1: The **Environmental Protection Agency** removed a major legal obstacle to a plan to create the first permanent U.S. nuclear waste repository in an undergound cavern near Carlsbad, N.M. The agency gave the **Department of Energy** authority under the nation's hazardous waste law to entomb up to 8500 barrels of chemical and radioactive waste in an experimental program to test the effectiveness of the US $1 billion repository, whose opening has been delayed for two years.

NOV 2: **Delta Electronics**, a Taiwanese manufacturer of power supply equipment for electronic products, said it will set up a plant near Glasgow, Scotland, that will employ 570 people.

NOV 2: The **U.S. Court of Appeals for the District of Columbia Circuit**, striking down a "one-stop" licensing procedure adopted by the **Nuclear Regulatory Commission (NRC)** in 1989, ruled that the NRC could not give permission for operation of a nuclear plant before it is built.

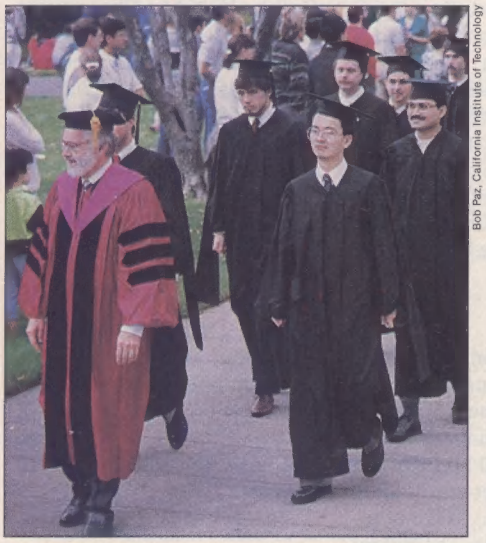
NOV 6: Residents in Prescott, Ore., voted to continue operation of the **Trojan Nuclear Plant**, even though certain safety conditions requested in a special ballot measure (reported in the November Newslog) were not guaranteed.

Preview:

DEC 17: A major **National Academy of Engineering** report, "National Interests in an Age of Global Technologies," is to be published today. The report addresses how the changing role of international companies is affecting U.S. policy options.

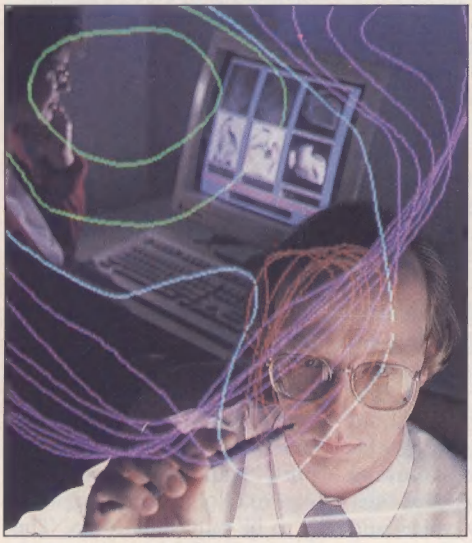
Coordinator: Sally Cahur

IEEE
SPECTRUM
VOLUME 27 NUMBER 12 DECEMBER 1990



Bob Paz, California Institute of Technology

32 Nobel Laureate William A. Fowler and Caltech graduates, class of '90



Siemens Corp.

57 Siemens researcher analyzes computer-aided three-dimensional simulation

Spectral lines

31 **College ($) woes/Instant cachet**
Donald Christiansen
Paying for education/Clad in reflected glory

Special report: engineering careers

32 **'90s employment** *Trudy E. Bell*
32 **Job security**
36 **Vulnerable EEs**
39 **Driving forces**
42 **Survival guide**

44 **Precollege math/science** *Katherine T. Chen*
Improving students' skills

49 **Whistle-blowing** *Karen Fitzgerald*
Not always a losing game

Applications/Perspective

53 **Software workstations**
Steve Hoffman, Giora Ben-Yaacov
One-stop shopping for utilities

64 **Japan space robots**
William L. Whittaker, Takeo Kanade
Automating space exploration

68 **The compleat fish story** *Glenn Zorpette*
Utilities to restore migratory populations

71 **Keithley's phantom repeater** Spectrum *staff*
Applying wartime technology

72 **Electronics on wheels** *Ronald K. Jurgen*
'91 car models

Careers

57 **Germany's engineering giant** *Fred Guterl*
Siemens enhances its competitiveness

61 **A powerhouse engineer** *Tekla S. Perry*
Narain Hingorani turns visions into reality

The Institute

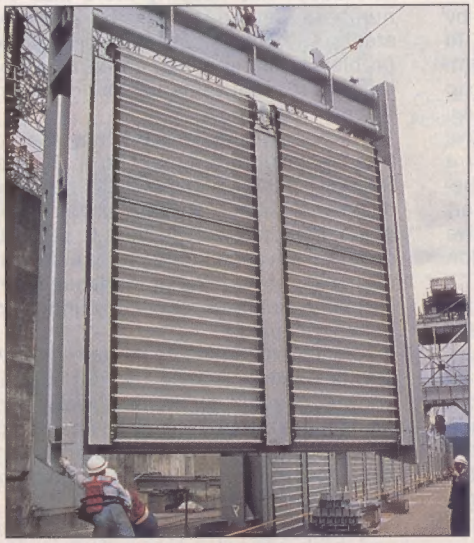
76 **IEEE honors**

Cover: Artist James Yang portrays today's EE confronting complex professional issues as an anguished engineer being pulled in different directions simultaneously. See p. 32.

3 Newslog
6 Speakout
8 Calendar
11 Books
16 Forum
24 Innovations
26 Engineer at large
29 Program notes
78 Faults & failures
79 EEs' tools & toys
91 Annual index
97 Reader guide
106 Scanning THE INSTITUTE
106 Coming in *Spectrum*

Semiconductor Research Corp. Competitiveness Foundation

Program to boost student skills includes lessons on power for teachers 44



U.S. Army Corps of Engineers

The submerged screen deflects migratory fish from hydroturbine blades 68

IEEE SPECTRUM (ISSN 0018-9235) is published monthly by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. © 1990 by The Institute of Electrical and Electronics Engineers, Inc. Cable address: ITRIPLEE. Telex 236-411. Telecopier: 212-705-7589.

ANNUAL SUBSCRIPTIONS. IEEE members: $9.00 included in dues. Nonmembers: $24. Libraries/institutions: $114.

SINGLE COPIES. Members: $7.50 first copy, $15 per additional copy. Nonmembers: $15.

MICROFICHE SUBSCRIPTIONS. Members: $15. Nonmembers and libraries: $114.

POSTMASTER: Please send address changes to *IEEE Spectrum*, c/o Coding Department, IEEE Service Center, Box 1331, Piscataway, N.J. 08855. Second Class postage paid at New York, N.Y. and additional mailing offices.

Printed at 8649 Hacks Cross Rd., Olive Branch, Miss. 38654.

IEEE Spectrum is a member of the Audit Bureau of Circulations, the Magazine Publishers of America, and the Society of National Association Publications.

The Audit Bureau MPA SSAP

Schools miss out on dyslexic engineers

The engineering profession in the United States is being denied potentially innovative engineers by the present school system. As it is now structured, it screens out and discourages students at elementary, secondary, and undergraduate levels who have abilities similar to those of a large number of presently practicing engineers, most of whom graduated before 1960. That innovative group, trained on vacuum tube technology, developed semiconductor electronics and computers, lasers, optical communications, satellite communications—and put a man on the moon.

I believe that a significant portion of these engineers are right-brain-dominant and/or compensated dyslexics.

I began reading about dyslexia 10 years ago, when my daughter was diagnosed as dyslexic. In its severe form, dyslexia inhibits the ability to read and learn. I realized that I myself was a mild, but compensated, dyslexic.

Since 1957, I have worked as a design and development engineer in advanced radar systems and particle accelerators. In considering my peers over the last 30 years, I have concluded that many of them were strongly right-brained persons or compensated dyslexics like me.

I entered engineering school because it seemed to offer a good match to my interests in science, mechanical devices, and the study of how things worked; I also was drawn to engineering school's basically nonverbal courses. Although I was unaware of it, the selection was strongly influenced by my dyslexia.

Under the educational setup today, the thinking processes of a right-brain-dominant person or a dyslexic do not mesh well with the learning process established by the left-brain-dominant school system. To resolve the conflict and keep up, the right-brain-dominant person and the dyslexic must invent novel learning processes. They hone these processes until they have converted what many would consider a handicap into an asset. Those who become engineers and scientists—Albert Einstein is one example—develop creative and innovative ways of storing information and making connections.

But because there is no recognition of, let alone allowance for, these different thinking processes, many right-brain-dominant people and dyslexics give up and drop out of school rather than continue to struggle. My comments are made to prompt academia and the IEEE (as the voice of our engineering community) to become more aware of the problem. Only after it is recognized can work begin toward a solution.

The problem stems from the way the brain is organized. It has two specialized information-processing functions: the logical/verbal (or digital-computer-like) left brain, and the artistic/spatial/intuitive (analog computer) right brain.

Ideally, when a problem is presented, the brain will automatically select which side is best suited to solve the problem, and data are transferred back and forth between the two. However, the dominant side will attempt to do most of the information processing, excluding the other side.

The left-brain-dominant individual thinks by forming textual concepts, while the right-brain-dominant individual thinks by forming visual images. Characteristic of the right-brain-dominant engineer is the ability to study a problem by visualizing it, intuitively jumping to the solution, and then filling in the intervening steps.

The right brain can also match the stored results of previous designs (modifying, turning, or twisting them as required) until an acceptable match that can become the start of a new design is achieved. When designing hardware systems, the right-brain engineer can visualize the overall design. Developing unusual approaches to a problem often results in state-of-the-art concepts that would not have been contemplated in a "normal" logical development thinking process that could lead to not seeing the forest for the trees.

Such creativity, innovation, and flexibility are considered an engineer's greatest assets. But people who possess these qualities are often penalized by the regimentation of school.

Literature on dyslexia highlights the extreme cases, which are generally recognized in the school system. But mild dyslexics must compensate on their own. Treated as slow learners, late bloomers, or lazy students, mild dyslexics respond with anger toward the school system because they know the material but cannot output the data as quickly as their peers.

The biggest problem is difficulty in doing certain rote functions that others find easy—like keeping more than five numbers (telephone numbers or constants) straight in memory. They also have problems with spelling, omitting or doubling words in a sentence, or not dotting i's and crossing t's.

The compensated dyslexic engineer will often resist admitting that he or she is afflicted, in part because the public equates dyslexia with lack of intelligence. The engineer who has worked hard to get a degree and advance in the profession fears the return of feelings of inadequacy and stupidity usually experienced during earlier school years.

A feeling of "sneaking through" the system is common. Once the dyslexic acknowledges the problem, however, and reads more about it, he or she can begin to cope with resentment and anger and deal more effectively with feelings of low self-esteem that may still exist.

If the schools, particularly elementary and high schools, acknowledged that these problems exist for some students, they would have to tailor the curriculum to account for the differences in the learning process. Worse yet, those who manage the system might have to stop substituting slick prepackaged math and science "learning modules."

Elementary schools, where the problem begins, too quickly categorize students as unable to learn science and mathematics. The prepackaged courses are taught and graded on a rote memory basis, since many of the teachers have little to no mathematics or science training. Or, students get canned explanations from a high-quality teacher who may not be allowed to deviate from the module format. This rigidity and the need to parrot answers discourage the probing and inquiry needed for science and mathematics. They certainly do not reward or stimulate creative thinking.

Looking back on my undergraduate days, I estimate that about one-third of engineering freshmen dropped out because they were predominantly right-brained or mild dyslexics and found it hard to follow standard explanations. They also had trouble following all-mathematical explanations delivered by teaching assistants speaking poor English. But the problem is compounded because the type of student entering engineering school now is different from the student of the 1940s and 1950s. There is far more screening out today of right-brained and moderately dyslexic students in high school and in the first year of college; these students are urged to try other fields.

If the United States is to advance its position in the engineering sciences, the school system must be made aware of these struggles of dyslexic and right-brained students to adapt to an education system that is so strongly left-brained and memory oriented. I believe that screening for right-brain or left-brain dominance and dyslexia should be required on entering elementary school.

By the time the students enter college, such screening could identify potentially intuitive and innovative engineers. And at earlier schooling levels, only high-quality teachers must teach math and science, in order to give students a firm foundation on which to build advanced concepts.

Colleges must also stop using foreign-born teaching assistants speaking poor English and bring full professors and their knowledge back into the classroom. And there must be more communication between academia and practicing engineers. The school systems must adjust their curricula to reflect the basic knowledge needed by engineers in their everyday work.

Unfortunately, too many companies and laboratories will only hire graduates with a B or better grade-point average, which is no indication of an engineer's ingenuity. These potential employers should instead keep an open mind about right-brain and dyslexic students, who could fill positions where their innovative and intuitive approaches to problems could be utilized.

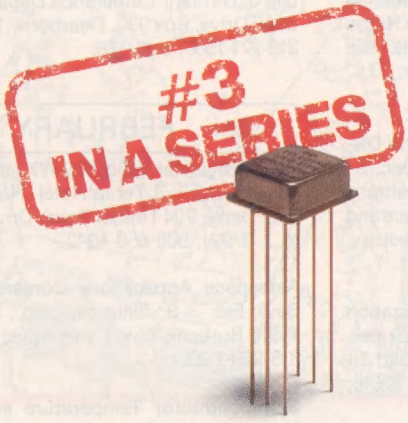
—Walter W. Frey

Walter W. Frey (SM), an electrical engineer for more than 30 years, is now with the accelerator department at Brookhaven National Laboratory, Upton, N.Y.

Coordinator: Alfred Rosenblatt

SOLID STATE RELAY

Our FB Series military solid-state relay features high speed and low off-state leakage.



ACTUAL SIZE

Here's what you get:

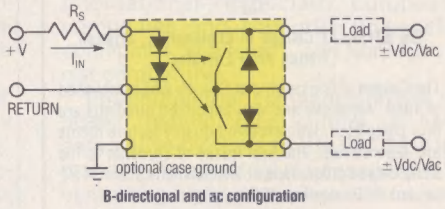
- Availability to pending DESC drawing 89116 with screening to "W" and "Y" levels of MIL-R-28750.
- High-voltage output
- Very-low leakage current (200 nA)
- DC or bi-directional power FET output (see wiring diagrams)
- Ideal for ATE applications
- Optical isolation
- Fast switching speed
- Adjustable turn-on times
- Low profile 6-pin mini-DIP
- Cost efficiency

Review the electrical characteristics below and call us for immediate application assistance.*

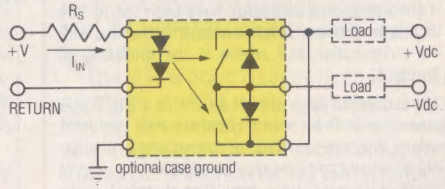
INPUT ELECTRICAL CHARACTERISTICS (–55° to +105° unless otherwise noted)			
	Min	Max	Units
Continuous Input Current (I_{IN})	10	50	mA_{DC}
Input Current (Guaranteed On)	10		mA_{DC}
Input Current (Guaranteed Off)		100	μA_{DC}
Input Voltage Drop at (I_{IN}) = 25mA		3.25	V_{DC}

OUTPUT ELECTRICAL CHARACTERISTICS (–55° to +105° unless otherwise noted)				
Part Number	**FB00CD**	**FB00FC**	**FB00KB**	**Units**
Bidirectional Load Current (I_{LOAD})	±1.0	±0.50	±0.25	A_{DC}/A_{PK}
DC Load Current (I_{LOAD})	2.0	1.0	0.5	A_{DC}
Bidirectional Load Voltage (V_{LOAD})	±80	±180	±350	V_{DC}/V_{PK}
DC Load Voltage (V_{LOAD})	80	180	350	V_{DC}
ON-Resistance (R_{ON}) at (I_{LOAD}) max.	0.72	1.8	12.9	Ohms
Turn-On Time (T_{ON})	800	800	500	µs
Turn-Off Time (T_{OFF})	300	600	500	µs

Notes: 1. A series resistor is required to limit continuous input current to 50mA (peak current can be higher).
2. Rated input current is 25mA for all tests.
3. Loads may be connected to any output terminal.
4. ON resistance shown is for the bidirectional configuration. The DC ON resistance is ¼ of these values.



B-directional and ac configuration



DC configuration

"CREATING THE STANDARD OF THE FUTURE"

TELEDYNE SOLID STATE
A Division of Teledyne Relays

*For immediate application assistance call 1-800-284-7007.

Teledyne Solid State, 12525 Daphne Avenue, Hawthorne, California 90250.

Circle No. 9

MEETINGS ☐ CONFERENCES AND CONVENTIONS

IEEE members attend more than 5000 IEEE professional meetings, conferences, and conventions held throughout the world each year. For more information on any meeting in this guide, write or call the listed meeting contact. Information is also available from: Conference Services Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 908-562-3878; submit conferences for listing to: Rita Holland, *IEEE Spectrum*, 345 E. 47th St., New York, N.Y. 10017; 212-705-7569.

For additional information on hotels, conference centers, and travel services, see the Reader Service Card.

DECEMBER

1990 International Electron Devices Meeting (IEDM/IEEE); Dec. 9-12; San Francisco Hilton and Towers; Melissa Widerkehr, IEDM 1990, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

Second IEEE Symposium on Parallel and Distributed Processing-SPDP (COMP); Dec. 9-13; The Colony Parks Hotel, Dallas; Behrooz Shirazi, Department of Computer Science and Engineering, Southern Methodist University, Dallas, Texas 75275-0122; 214-692-2874.

San Diego Workshop on Volume Visualization (COMP et al.); Dec. 10-12; San Diego Supercomputer Center, La Jolla, Calif.; T. Todd Elvins, SDSC, Box 85608, San Diego, Calif. 92018; 619-534-5128.

Workshop on Heterogeneous Database Systems (COMP); Dec. 11-13; Northwestern University, Evanston, Ill; IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036; 202-371-1013.

JANUARY 1991

Fourth CSI/IEEE International Symposium on VLSI Design (COMP et al.); Jan. 5-8; New Delhi, India; Y.K. Malaiya, Computer Science Department, Colorado State University, Fort Collins, Colo. 80523; 303-491-7031; or D. Roy Chowdhury, Gateway Design Automation, SDF- A-1, Noida Export Processing Zone, P.O. NEPZ, Noida-201305, UP, India; (91+57) 366 2342.

ITAC Intelligent Tuning and Adaptive Control (IEEE et al.); Jan. 15-17; Mandarin Hotel, Singapore; ITAC 91 Secretariat; Conference and Exhibition Secretariat Pte. Ltd., 6E Mount Sophia, Singapore 0922, (65) 337 3476.

Annual Reliability and Maintainability Symposium and Exhibits Program (IEEE et al.); Jan. 29-31; Orlando Marriott, Orlando, Fla.; Irwin A. Feigenbaum, Vitro Corp., 600 Maryland Ave., S.W., Suite 300W, Washington, D.C. 20024; 202-646-6327.

International Conference on Wafer Scale Integration (COMP et al.); Jan. 29-31; Fairmont Hotel, San Francisco; Terry Chappell, Chappell Enterprises; 408-662-1936.

Manufacturing Training Courses (SME); Jan. 29-31; Orlando Exposition Centre, Orlando, Fla.; Lori J. Birman, Conference Department, One SME Drive, Box 930, Dearborn, Mich. 48121; 313-271-1500, ext. 378.

FEBRUARY

Power Engineering Society Winter Meeting (PE et al.); Feb. 3-7; Penta Hotel, New York City; J. G. Derse, 704 Timber Brook Dr., Bedminster, N.J. 07921; 908-658-4042.

Aerospace Applications Conference (South Bay); Feb. 3-8; Telluride, Colo.; Steve Swift, 15216 Burbank Blvd., Van Nuys, Calif. 91411; 818-989-1133.

Semiconductor Temperature and Thermal Management Symposium-SEMI-THERM (CHMT); Feb. 12-14; Phoenix, Ariz.; C/S Communications, Box 23899, Tempe, Ariz. 85285-3899; 602-967-7444.

International Solid State Circuits Conference (ISSCC et al.); Feb. 13-15; San Francisco; Diane Suiters, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4255.

11th Nonvolatile Semiconductor Memory Workshop (ED); Feb. 19-22; Hyatt Regency Hotel, Monterey, California; Theodore Dellin, Sandia National Laboratories, Division 2146, Box 5800, Albuquerque, New Mexico 87185; 505-844-2044.

Seventh International Conference on Artificial Intelligence Applications-CAIA 91 (COMP et al.); Feb. 24-28; Fontainebleau Hilton, Miami Beach, Fla.; IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

Computer Society Conference-COMPCON Spring '91 (COMP); Feb. 25-March 1; Cathedral Hill Hotel, San Francisco; COMPCON Spring '91, IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

Winter Convention on Aerospace and Electronic Systems-Wincon '91 (AES et al.); Feb. 26-28; Los Angeles; George Oltman, 23411 Dolorosa, Woodland Hills, California 91367; 818-341-4010.

s. This prompted as-
bel laureate Fred Hoyle
iking's life tests as "the
:ussed, misinterpreted,
periments man has un-

to its position, although
that the mass spectrom-
vas not sensitive enough
other results. In a care-
st, a mass spectrometer
e sent to Mars detected
:arctic soil. But a labora-
d organics, ■■ did a re-
vn experiment.
ntradict Wilford's asser-
ults of the [mass spec-
ent, it turned out, would
n evaluating the findings
eriments on the lander
:ally to search for signs
significant reason to
ectrometer should have
anic matter has been
ibers where ■ simulated
e was continuously ex-
ed sunlight—including
omponent that Wilford
why no organic matter
ars.
NASA's revival of the life
rrent thinking that life
on Mars in an earlier, liq-
leed, NASA is now de-
to look for microbial fos-
heory is that life became
net lost atmosphere and
t where liquid water be-
e. Wilford might have
me lichen on Earth exist
apor as their sole source
Viking detected fogs and
lars.
ote concerning public
account of U.S. and So-
ned expeditions to Mars
lons against possible

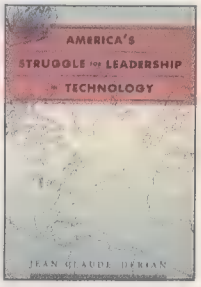
to the life issue, Wilford,
s the window open ■
d have been more inves-
ly in light of the sig-
ssue. To his credit, how-
ncourage continued
he history of water on
the discovery of some
or fossil, we will have ex-
ledge of the conditions
an evolve and survive in

appendix, ■ chronology
Mars from 1960 to 1989,
he second, ■ table of
planets in the solar sys-
ated, failing to mention,
itrogen is a component
ere. This was one of Vik-
nd is important in terms
he book concludes with
t will keep the Mars buff
least ■ couple of sum-

—*Gilbert V. Levin*

hairman and president of Beltsville, Md., a firm he founded in 1967 to do research into and provide products and services related to the environment and health. An environmental engineer by training, he became interested in life on Mars while developing sensitive techniques for the detection of microorganisms. That work led to his participation in the Mariner 9 and Viking missions to Mars. He has been awarded the NASA Public Service Medal, the Newcomb Cleveland prize of the American Association for the Advancement of Science, and some 50 patents. He received his BE, MS, and Ph.D. degrees from Johns Hopkins University in Baltimore, Md.

America's Struggle for Leadership in Technology. *Derain, Jean-Claude,* MIT Press, Cambridge, Mass., 1990, 309 pp., $29.95.



This book is enjoying ■ spurt of popularity with U.S. readers, and it is not hard to see why. After all, here is a non-U.S. writer bringing a fresh insight to a national problem, and we all know that outsiders always see more clearly than insiders. Even more appealing, Derain has a vision where others seem to have none.

In his view, the U.S. technology infrastructure is composed of a "sheltered" technological culture that is largely a product of Government (particularly military) nurturing since World War II and an "exposed" technological culture spurred by entrepreneurial fervor unmatched in other nations.

Today, companies in that "sheltered" technological culture are enjoying less Government support. They are technically falling behind the purely commercial sector, are increasingly threatened by international—especially European—companies and consortia (themselves sometimes "sheltered"), and (surprise!) are not competitive.

Entrepreneurial companies in the "exposed" technological culture are being eaten alive by firms in the Far East that manage the seemingly impossible feat of combining high levels of innovation, short time-to-market, large-scale manufacturing and financial resources, and vertical integration.

There is a good deal of truth in Derain's premise, and he does ■ masterful job of tracing the mainstreams of Government involvement in R&D and technology in the United States since World War II (although he does have the non-U.S. observer's usual fixation on the Strategic Defense Initiative). Unfortunately, he hardly touches on, or completely ignores, a substantial number of issues believed to impact the U.S. competitive posture in technology. These include:

- The Federal deficit and the personal savings rate in the United States; the cost of capital for R&D investments and productivity-enhancing investments; the "quarterly-profit syndrome" and volume stock trading by large institutional investors; and the possible impact of leveraged

MEETI
AN

IEEE members attend
tions held throughout t
write or call the listed m
Department, IEEE Ser
3878; submit conferen
York, N.Y. 10017; 212-
For additional inform
Service Card.

DECEM

1990 International Elec
(IEDM/IEEE); Dec. 9-12
and Towers; Melissa Wid
15th St., N.W., Suite 3
20005; 202-347-5900.

Second IEEE Symposiu
tributed Processing-SP
13; The Colony Parks H
Shirazi, Department of
Engineering, Southern
Dallas, Texas 75275-012

San Diego Workshop or
(COMP et al.); Dec. 10-
computer Center, La Jo
vins, SDSC, Box 85608,
619-534-5128.

Workshop on Heteroge
tems (COMP); Dec.
University, Evanston, Ill.
ety, 1730 Massachusetts
ton, D.C. 20036; 202-37

JANUAR

Fourth CSI/IEEE Interna
VLSI Design (COMP e
Delhi, India; Y.K. Malaiy
Department, Colorado
Collins, Colo. 80523; 30
Chowdhury, Gateway
SDF- A-1, Noida Export
NEPZ, Noida-201305, U
2342.

ITAC Intelligent Tuning
(IEEE et al.); Jan. 15-17;
gapore; ITAC 91 Secreta
Exhibition Secretariat
Sophia, Singapore 092

Annual Reliability and M
sium and Exhibits Progr
29-31; Orlando Marriott
A. Feigenbaum, Vitro Co
S.W., Suite 300W, Was
202-646-6327.

International Conferenc
tegration (COMP et al.);
Hotel, San Francisco; Te
Enterprises; 408-662-19

Post Office Will Not Deliver Mail Without Proper Postage

IEEE SPECTRUM
IEEE SERVICE CENTER
ATTN: CODING DEPT
445 HOES LANE
PO Box 1331
PISCATAWAY NJ 08855-1331

Mars Beckons. *Wilford, John Noble,* Alfred A. Knopf, New York, 1990, 244 pp., US $ 24.95.

Mars beckons, indeed! John Noble Wilford charts the supreme adventure that awaits humankind. His book is replete with the romance, facts, and questions that will propel our spacecraft to the red planet. Wilford makes abundantly clear why Mars alone among the planets of the solar system can—and will—be the destination of our first giant step into the cosmos.

He describes in massive detail the history of our interest in Mars, the present state of our knowledge, and the likely course of future exploration. Starting with the ancients' interest in the stars and planets, he skillfully guides the reader through theories, facts, and projections, weaving in some of the more familiar fictions about Mars. The book culminates with the U.S. and Soviet ventures into space and looks ahead to multinational projects to explore and populate Mars and beyond.

The author indicts the U.S. space program for its post-Apollo loss of direction and makes the point that now is the time for decisions that will insure the future role of the United States in space. He provides a glimpse of the technologies that will be needed (some already under development) to support humans during the trip to Mars and after landing there. The style is succinct and readable, befitting Wilford's occupation as a newspaper reporter.

From the author's perspective, "The big question about Mars still concerns life." The search for life on Mars was the motivating force behind the National Aeronautics and Space Administration's (NASA's) US $1 billion Viking mission, which landed on the planet in 1976. A brilliant technological success, Viking, alas, provided mixed results on the key issue of life.

In a Viking experiment I designed, Mars soil moistened with radioactive nutrients evolved radioactive gas—but that *did not* happen when the soil was preheated to sterilize it. This result is strong evidence of living organisms in the soil. However, another instrument, the gas chromatograph mass spectrometer, designed to detect organic matter (the stuff of life), found no such organisms in the Mars soil.

Since those experiments, various scientists have tried to explain the radioactive gas on Mars as a by-product of an inorganic chemical reaction, possibly involving peroxide. However, none have been able to duplicate the result in the laboratory.

Vexed at the prospect of declaring life on Mars based on one experimental result, but not willing to write off the possibility supported by a conflicting result, NASA hedged by announcing that no positive evidence had been found for life on Mars *at the Viking sites*. This prompted astronomer and Nobel laureate Fred Hoyle to characterize Viking's life tests as "the most widely discussed, misinterpreted, and expensive experiments man has undertaken."

NASA has held to its position, although it was later shown that the mass spectrometer sent to Mars was not sensitive enough to contradict the other results. In a carefully controlled test, a mass spectrometer identical to the one sent to Mars detected no organics in Antarctic soil. But a laboratory assay did find organics, as did a recreation of my own experiment.

These facts contradict Wilford's assertion that "the results of the [mass spectrometer] experiment, it turned out, would be unambiguous in evaluating the findings of the three experiments on the lander designed specifically to search for signs of life." Another significant reason to doubt the mass spectrometer should have been cited. Organic matter has been produced in chambers where a simulated Mars atmosphere was continuously exposed to simulated sunlight—including the ultraviolet component that Wilford says is the reason why no organic matter could exist on Mars.

He reports on NASA's revival of the life issue, and on current thinking that life *probably* did arise on Mars in an earlier, liquid-water era. Indeed, NASA is now developing methods to look for microbial fossils on Mars. The theory is that life became extinct as the planet lost atmosphere and cooled to the point where liquid water became unavailable. Wilford might have mentioned that some lichen on Earth exist on atmospheric vapor as their sole source of water, and that Viking detected fogs and ground frost on Mars.

An alarming note concerning public policy is Wilford's account of U.S. and Soviet plans for manned expeditions to Mars with no precautions against possible microorganisms.

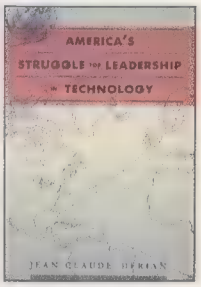
When it comes to the life issue, Wilford, like NASA, leaves the window open a crack. But he could have been more investigative, especially in light of the significance of this issue. To his credit, however, he does encourage continued investigation of the history of water on Mars: "If it leads to the discovery of some kind of life, active or fossil, we will have expanded our knowledge of the conditions under which life can evolve and survive in the universe."

The book's first appendix, a chronology of the missions to Mars from 1960 to 1989, is quite useful. The second, a table of characteristics of planets in the solar system, is too abbreviated, failing to mention, for instance, that nitrogen is a component of Mars' atmosphere. This was one of Viking's discoveries and is important in terms of the life issue. The book concludes with a bibliography that will keep the Mars buff entertained for at least a couple of summers.

—*Gilbert V. Levin*

Gilbert V. Levin is chairman and president of Biospherics Inc. in Beltsville, Md., a firm he founded in 1967 to do research into and provide products and services related to the environment and health. An environmental engineer by training, he became interested in life on Mars while developing sensitive techniques for the detection of microorganisms. That work led to his participation in the Mariner and Viking missions to Mars. He has been awarded the NASA Public Service Medal, the Newcomb Cleveland prize of the American Association for the Advancement of Science, and some 50 patents. He received his BE, MS, and Ph.D. degrees from Johns Hopkins University in Baltimore, Md.

America's Struggle for Leadership in Technology. *Derain, Jean-Claude,* MIT Press, Cambridge, Mass., 1990, 309 pp., $29.95.



This book is enjoying a spurt of popularity with U.S. readers, and it is not hard to see why. After all, here is a non-U.S. writer bringing a fresh insight to a national problem, and we all know that outsiders always see more clearly than insiders. Even more appealing, Derain has a vision where others seem to have none.

In his view, the U.S. technology infrastructure is composed of a "sheltered" technological culture that is largely a product of Government (particularly military) nurturing since World War II and an "exposed" technological culture spurred by entrepreneurial fervor unmatched in other nations.

Today, companies in that "sheltered" technological culture are enjoying less Government support. They are technically falling behind the purely commercial sector, are increasingly threatened by international—especially European—companies and consortia (themselves sometimes "sheltered"), and (surprise!) are not competitive.

Entrepreneurial companies in the "exposed" technological culture are being eaten alive by firms in the Far East that manage the seemingly impossible feat of combining high levels of innovation, short time-to-market, large-scale manufacturing and financial resources, and vertical integration.

There is a good deal of truth in Derain's premise, and he does a masterful job of tracing the mainstreams of Government involvement in R&D and technology in the United States since World War II (although he does have the non-U.S. observer's usual fixation on the Strategic Defense Initiative). Unfortunately, he hardly touches on, or completely ignores, a substantial number of issues believed to impact the U.S. competitive posture in technology. These include:

- The Federal deficit and the personal savings rate in the United States; the cost of capital for R&D investments and productivity-enhancing investments; the "quarterly-profit syndrome" and volume stock trading by large institutional investors; and the possible impact of leveraged

buyouts over the last decade.

- The state of U.S. education; and investment by U.S. corporations in remedial education for entry-level workers.
- Access to international markets; support of selected industries by non-U.S. Governments; local content rules abroad; protection of U.S. intellectual property abroad; "dumping" in the United States and evasion of antidumping efforts by using intermediary countries; international cartels and possible price-fixing; non-U.S. investment in U.S. high-technology firms as it relates to antitrust; and non-U.S. lobbying in the United States and the hiring of former U.S. Federal officials as agents for overseas entities.
- Product liability and litigation; Federal regulations regarding workplace safety and health; the content and ambiguity of antitrust legislation; tax legislation, regulation, and interpretation as it affects capital investment, savings, and R&D; and telecommunications regulation as it affects investment in the U.S. information infrastructure.
- Accounting systems as they affect manufacturing; mass-production and quality-control strategies; and differing customer needs worldwide.
- Management-labor relations; vertical integration; and relationships between manufacturers and their lower-tier suppliers.
- Federal R&D investments in U.S. universities; non-U.S. students at U.S. universities; and immigration policies.

America's Struggle for Leadership in Technology is too incomplete to be balanced and useful. After all, its subject encompasses perhaps the most important group of issues defining the quality of life in the United States during the next decade and into the next century.

—*Craig Fields*

Craig Fields is president of Microelectronics and Computer Technology Corp. in Austin, Texas. He was formerly director of the Defense Advanced Research Projects Agency (Darpa).

BOOKS IN BRIEF

Supercomputers. *Chorafas, Dimitri N., and Steinmann, Heinrich,* McGraw-Hill, New York, 1990, 338 pp., US $49.95.

This book is not, strictly speaking, a work on supercomputers in the sense that other volumes use this word in their titles, such as *The Supercomputer Era* by Sidney Karin and Norris Parker Smith, or *Supercomputers and Their Use* by Christopher Lazou. Rather, it attempts to cover both artificial intelligence and supercomputers, which are usually viewed as topics of interest to different reader communities. To cover both in a single book is perfectly reasonable, but to cover them under the title *Supercomputers* is to mislead the reader, because about half of the book is on subjects other than supercomputers.

Books in Print lists 29 entries under Chorafas's name, and six, including this book, as collaborations with Steinmann. Chorafas is an international consultant and Steinmann is the executive vice president of the Union Bank of Switzerland. Their previous books cover a wide spectrum of subjects, but neither author is an expert on supercomputing. Rather, they depend for the content of this book on their interpretations of interviews with experts from 55 institutions.

The value of the expert-interview style is that the reader gains ready access to the ideas of many experts. However, when the interviewers lack extensive knowledge of the field, the experts' opinions are filtered, and the result is a mixture of expert and nonexpert opinions. Inevitably, some of the content is shallow or erroneous.

For example, the crossbar and hypercube diagrams in Fig. 2-1 of Chapter 2 are simply wrong: the crossbar diagram is a diagram of a fully connected system, and the hypercube diagram shows the outside of an ordinary cube with 27 nodes. By definition, the number of nodes in a hypercube is always a power of two.

In Chapter 5, the authors correctly define an array processor as "a high-speed computational device attaching to a general-purpose host," but then erroneously identify Cray Research computers as array processors.

Chapter 10 discusses "The ETA Superconducting Computer" (p. 208), but this is nonsense. The ETA-10 was not a superconducting computer. Rather, it was cooled

with liquid nitrogen, ■ cryogenic technology but not a superconductive (zero-resistance) one. Indeed, to include a whole chapter on a computer that is no longer in production while ignoring ongoing projects, such as IBM Corp.'s extensive efforts in high-performance computing, is a mistake in perspective that only someone unfamiliar with the field would make. That nonexperts would make such mistakes is perhaps to be expected; that McGraw-Hill would not have the content checked by an expert is ■ procedural error by the publisher.

There are other chapters on the Connection Machine from Thinking Machines; the iPSC/2 from Intel Scientific Computers, and Bolt, Beranek, and Newman's Butterfly systems. Other chapters include "The New-Generation Project in Japan," the "Japanese Thrust into 5GCs," "Idea Databases and Whole Document Search," and "Sixth Generation Computer Technology."

—Jack Worlton

Jack Worlton is an international consultant in supercomputing and a Laboratory Fellow at Los Alamos National Laboratory in New Mexico.

Coordinator: Glenn Zorpette

RECENT BOOKS

The IBM Personal Computer Upgrade Guide. *Sandler, Corey, and Badgett, Tom,* Howard W. Sams, New York, 1990, 285 pp., $22.95.

Electrical Wiring. *Seale Jr., Arthur C.,* Howard W. Sams, New York, 1990, 274 pp., $19.95.

Vector Models for Data-Parallel Computing. *Blelloch, Guy E.,* MIT Press, Cambridge, Mass., 1990, 255 pp., $37.50.

Learning with Interactive Multimedia. Eds. *Ambron, Sueann, and Hooper, Kristina,* Microsoft Press, Redmond, Wash., 1990, 383 pp., $24.95.

Gallium Arsenide Digital Integrated Circuit Design. *Long, Stephen I., and Butner, Steven E.,* McGraw-Hill, New York, 1990, 486 pp., $53.95.

The First Book of PFS: First Publisher. *Brown, Karen, and Bixby, Robert,* Howard W. Sams, New York, 1990, 308 pp., $16.95.

Introduction to DB2 Programming. Eds. *Tran, Viet G., Shreve, Theron, and Young, Nancy,* McGraw-Hill, New York, 1989, 198 pp., $27.95.

Innovating for Failure: Government Policy and the Early British Computer Industry. *Hendry, John,* MIT Press, Cambridge, Mass., 1990, 240 pp., $35.00.

Introduction to VLSI Design. *Fabricius, Eugene D.,* McGraw-Hill, New York, 1990, 406 pp., $48.95.

Using C with Curses, Lex and Yacc. *Schreiner, Axel T.,* Prentice-Hall, Englewood Cliffs, N.J., 1990, 257 pp., $36.

Electric Machinery, 5th Edition. *Fitzgerald, A.E., Kingsley, Charles Jr., and Umans, Stephen D.,* McGraw Hill, New York, 1990, 499 pp., $45.95.

Perspectives in Radio Frequency Identification. *Ames, Ron,* Van Nostrand Reinhold, New York, 1990, $25.95.

Microsoft Word for the Apple Macintosh. *Boom, Michael,* Microsoft Press, Redmond, Wash., 1990, 432 pp., $19.95.

Handbook of Semiconductor Silicon Technology. Eds. *O'Mara, William C., et al.,* Noyes Publications, Park Ridge, N. J., 1990, 795 pp., $96.

Alvey: Britain's Strategic Computing Initiative. *Oakley, Brian, and Owen, Kenneth,* MIT Press, Cambridge, Mass., 1990, 337 pp., $40.

Inside PC Tools Deluxe. *Nelson, Stephen,* Microsoft Press, Redmond, Wash., 1990, 416 pp., $22.95.

Automatic Control Systems. *Kuo, Benjamin C.,* Prentice-Hall, Englewood Cliffs, N.J., 1991, 760 pp., $56.

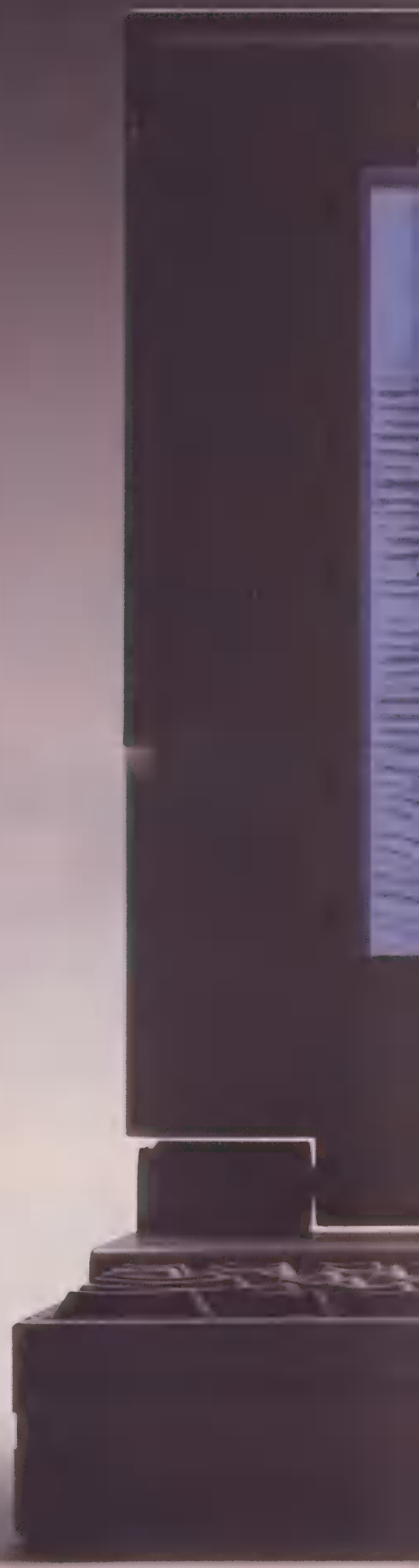
AI and Expert Systems (A Comprehensive Guide-C Language), 2nd Edition. *Levine, Robert I., Drang, Diane E., and Edelson, Barry,* McGraw-Hill, New York, 289 pp., $24.95.

Compaq introduces an 8½"×11" awesome display of power.

One look at our powerful new notebook PC, and you'll see why more FORTUNE 1000 companies choose COMPAQ portables and laptops over all others.* Now see it in person at your Authorized COMPAQ Computer Dealer.
Call 1-800-231-0900, Operator 138 for the location nearest you.
In Canada, 1-800-263-5868, Operator 138.

COMPAQ

It simply works better.



ACTUAL SIZE.

YOU'RE LOOKING AT THE NEW COMPAQ LTE 386s/20 PERSONAL COMPUTER. THE MOST POWERFUL NOTEBOOK PC ON THE PLANET.

■ YES, IT'S SMALL, BUT LOOK HOW BIG IT IS ON THE INSIDE.

■ STORES UP TO 30,000 PAGES. THE ONLY NOTEBOOK PC THAT OFFERS A 60-MB FIXED DISK DRIVE.

■ VGA DISPLAYS RAZOR-SHARP GRAPHICS IN 16 GRAY SHADES.

■ THE 20-MHz INTEL 386SX PROCESSOR WITH CACHE SETS YOUR PRODUCTIVITY ON FIRE.

■ AT A MERE 7.5 LB. WITH BATTERY, IT TRAVELS LIGHT.

■ THE 2-MB HIGH-SPEED RAM IS EXPANDABLE TO 10 MB.

■ MORE THAN 3 HOURS* BATTERY LIFE PLUS INTERNAL FAST CHARGE.

■ ADD A DESKTOP EXPANSION BASE FOR MORE OFFICE CAPABILITY.

■ TRAVEL MUCH? OUR WORLDWIDE WARRANTY ASSURES SERVICE IN OVER 60 COUNTRIES.

■ YOU CAN EVEN PLUG IN A MOUSE.

*Based on a Gallup Organization poll conducted for Computer Reseller News Benchmark Magazine. COMPAQ, Registered U.S. Patent and Trademark Office. Product names mentioned herein may be trademarks and/or registered trademarks of other companies.

Guarding against transients

I read François Martzloff's article "Protecting computer systems against power transients" [April, pp. 37–40] with interest and appreciation. I do think that in the statement "Nanosecond pulses do not propagate very far in power systems" [p. 38], Martzloff is referring to the fact that the high-frequency noise on transmission lines is greatly attenuated by the time it reaches a house, particularly by distribution transformers. If, however, you live on the same street as a ham operator or someone with an arc welder, or live near a substation or transmission line, some of the RF may be coupled into your house wiring and disrupt or damage your computer. Even worse is the very strong likelihood of damage if someone is operating a portable phone, citizens' band radio, or VHF portable near or in your house.

I think any or all of these possibilities are likely enough to result in large numbers of high-energy, high-frequency spikes getting into your computer. In these cases, it is important that suppression be effective up to nanosecond spikes and beyond. MOVs can be ineffective against these, and you may have to use faster devices.

This subject is always interesting and sometimes controversial, or maybe the other way around.

Ian A. Stewart
West Vancouver, B.C.
Canada

The author replies:
I completely agree with Stewart that controversial subjects are more interesting than those that are not, and also agree that radiated electromagnetic interference (EMI) can be a source of problems for computers. The article on power transients concerned transients that arrive at the computer by conduction along the wires, not those radiated directly into the computer circuitry.

High-frequency radiated interference would not be addressed by insertion of a surge suppressor in the power line. When RF radiation is coupled into the house wiring, I doubt that enough energy can be coupled to cause damage, but would be interested in hearing about case histories.

The article "Electrical fast transient tests: applications and limitations" [Martzloff & Leedy, *IEEE Trans.* IA-26 No. 1, Jan./Feb. 1990] shows how a spike of 5-nanosecond rise-time is stretched into tens of nanoseconds after propagating along typical conductors (no need for a distribution transformer to do this). There are power-line suppressors on the market that include EMI filters; these are intended for blocking in the kilohertz to megahertz range, not the gigahertz range of nanosecond rise-times. Thus, there seems to be little need for power-line transient suppressors with nanosecond—even shorter—response times.

Viewpoints on EMF radiation

I am proud to be even a minuscule part of the organization that can produce in its flagship publication the article "Electromagnetic fields: the jury's still out" by M. G. Morgan and I. Nair [August, p. 22], especially since the authors, with their impressive credentials, could easily be counted among those supporting the "no effects" cause. They produced a superb article.

As a "1930s' engineer" (albeit somewhat updated), I should have liked to see quantitative reference to the (horizontal) component of the strength of the Earth's magnetic field in the units quoted in magnetic fields. In attempting to correlate the microtesla with the gauss, I find that I should multiply by exactly 1 E-04, so that 0.2 gauss (typical of the Earth's field) is equivalent to 20 microteslas.

Also, with regard to electric blankets and shavers, it would seem practical to convert the power to dc. Would that not help avoid electromagnetic field effects? Electric blankets seem necessary at most to preheat the bed. My blanket is even equipped with a timer, usually set for about 15 minutes.

In conclusion, a statement for the "no effects" group might include the number of tests to date that have been performed on human beings, rather than on laboratory animals.

Sidney B. Williams
Lexington, Mass.

IEEE Spectrum has made a serious error in publishing the special report without including a single calculation to give the magnitude of the voltages that are actually induced inside the body by power-frequency fields. Thinking people who see these numbers would be extremely skeptical.

As a typical example, let us consider the effect of magnetic fields on brain nerve cells. Through Faraday's law, we can calculate the typical voltage induced by a 1-μT, 60-hertz magnetic field across a cell membrane. The result is about 0.1 nanovolt, which is extremely small. For comparison, the background voltages in the power-frequency range in the brain are the action potentials of nerve cells, which are typically 0.1-volt, 2-millisecond spike trains with repetition rates in the range of 1–100 Hz. What is the conceivable mechanism for damage from 60-Hz fields in the presence of spikes that are nine orders of magnitude larger?

In the face of this, it is inadequate to quote 95 percent confidence intervals, or no confidence intervals at all, in the article by Nair and Morgan. When there are many studies considering many effects, we would expect the results often to be significant at the 95 percent level through chance, personal bias, and unexplained confounding factors.

The work on the hazards of power-frequency fields has the characteristics of "pathological science," or "the science of things that aren't so," described by Nobel Laureate Irving Langmuir in a 1953 speech reprinted in the October 1989 issue of *Physics Today* during the cold-fusion controversy. Langmuir's speech is a sobering history of perverse effects in physics and their denouements. Some characteristics are that "the effect is of a magnitude that remains close to the limits of detectability," "fantastic theories contrary to experience are suggested," and "criticisms are met by *ad hoc* excuses." However, Langmuir ends on a positive note: "The ratio of supporters to critics rises up to somewhere near 50 percent and then falls gradually to oblivion."

Robert Langmuir and David Rutledge
Pasadena, Calif.

I have one comment and one question on the most interesting paper.

First, I strongly object to the following sentence: "Most experts we talk with privately give odds somewhere between 10 percent and 60 percent that within the next decade it will become clear that exposure to fields produces significant health risks" [p. 35]. More precisely, I would like to know:

- Who are these experts?
- What are their qualifications?
- Who pays them?
- Does the majority vote for 60 percent or 10 percent? In case of a bimodal distribution, are there differences between the two subpopulations?
- The word "significant" is used; the question is, compared to what risk?

Without such information, the sentence is meaningless to me.

Second, all the data used in the paper appear to be of U.S. origin. Given that the Netherlands, Belgium, northern France, and the Ruhr are extremely densely populated, I imagine that they must have lots of people living close to transmission lines. Are there any European data that corroborate, say, the Denver studies referred to in the paper?

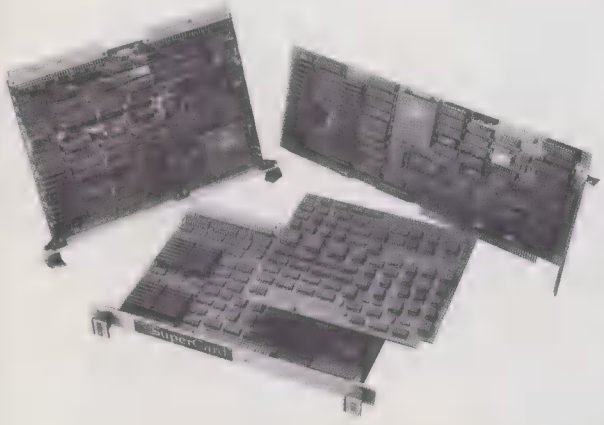
Charles A. Desoer
Berkeley, Calif.

The authors respond:
We are sorry reader Desoer does not like the sentence he quotes. We felt we had an obligation to convey some sense of experts' subjective judgment of the likelihood that there is a risk. If we had used words rather than numbers, Desoer might not have taken offense, but there is substantial evidence in the social science experimental literature that words such as

(Continued on p. 22)

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues.

Speed + Performance . . .
The SuperCard™ Family of i860 Vector Processors



The second generation of i860-based SuperCards™ is here... vector processors with GigaFLOPS system capability, concurrent I/O via secondary buses, large math libraries, FORTRAN and C development software... and, best of all, the *best price* on the market. The SuperCard family is compatible with VMEbus, ATbus, EISAbus and TURBOchannel platforms for hosts like Sun, HP, Motorola, Compaq, and DEC... here's what you get:

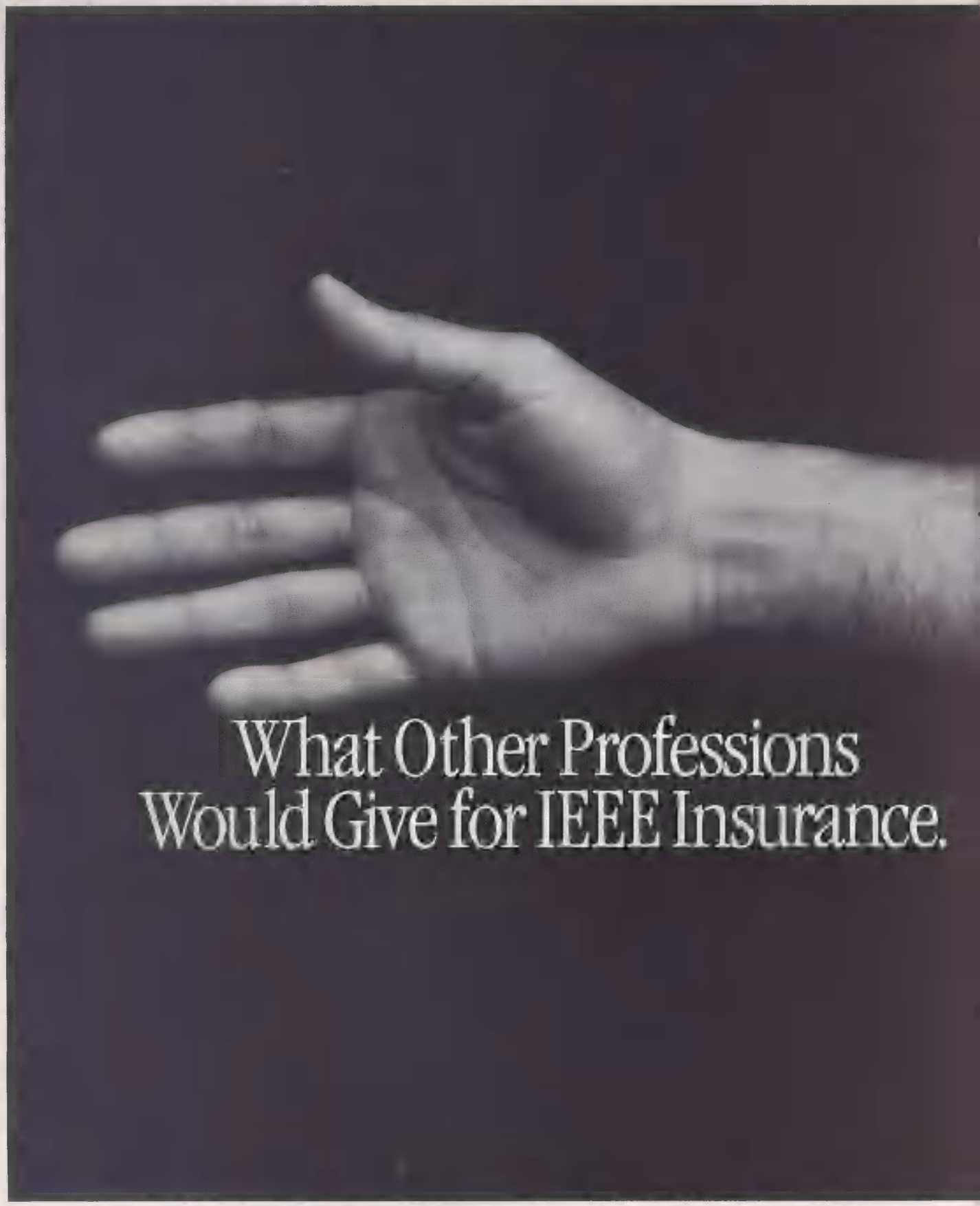
- 1024 complex FFT in 0.8 msec.
- 80 MFLOPS to 1.5 GFLOPS
- 160 MB/sec I/O
- Large memories
- pSOS+ Multiprocessing
- CASE Tools

CSPI

To find out how SuperCard can work for you, call: 1-800-325-3110 or 617-272-6020, (Fax 508-663-0150) or write CSPI, 40 Linnell Circle, Billerica, MA 01821.

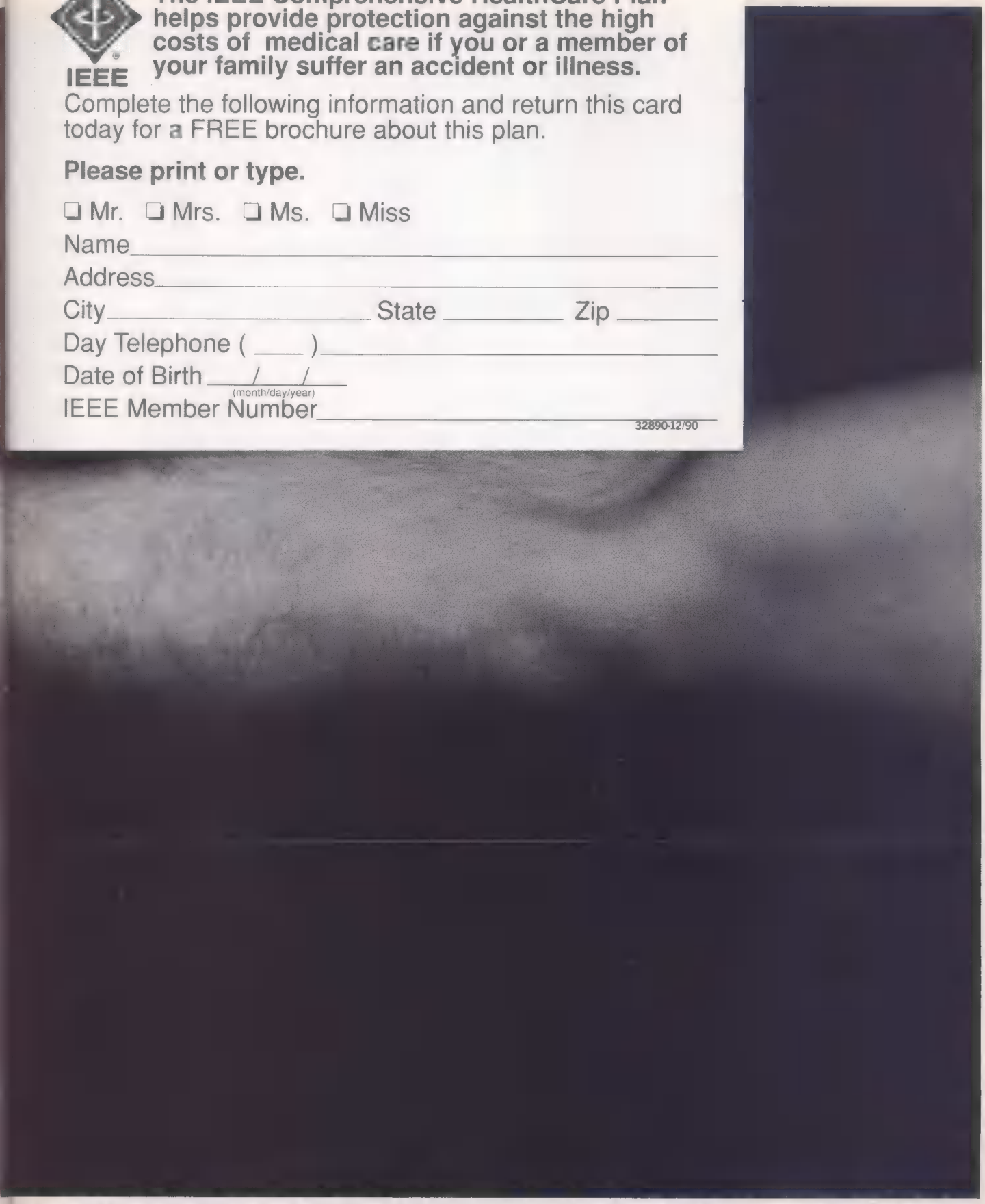
SuperCard is a trademark of CSP Inc., i860 is a trademark of Intel Corp.
TURBOchannel is ■ trademark of Digital Equipment Corp.
pSOS+ is a trademark of Software Components Group, Inc.

Circle No. 5



Your Association used group purchasing power to negotiate top quality insurance for members—at a very low price. We designed this coverage specifically for your professional needs.

Most plans cover the whole family and, as long as you remain a member of the Association, stay in effect no matter how often you change jobs. Your personal policy can even be



The IEEE Comprehensive HealthCare Plan helps provide protection against the high costs of medical care if you or a member of your family suffer an accident or illness.

IEEE

Complete the following information and return this card today for a FREE brochure about this plan.

Please print or type.

❑ Mr. ❑ Mrs. ❑ Ms. ❑ Miss

Name_____

Address_____

City_____ State _____ Zip _____

Day Telephone (____)_____

Date of Birth ___/___/___
(month/day/year)

IEEE Member Number_____

32890-12/90

tailored to suit your changing circumstances.

No wonder other professions would give their right arm for our insurance. Find out more about this benefit by calling 1-800-424-9883 (in Washington, D.C. call 457-6820).

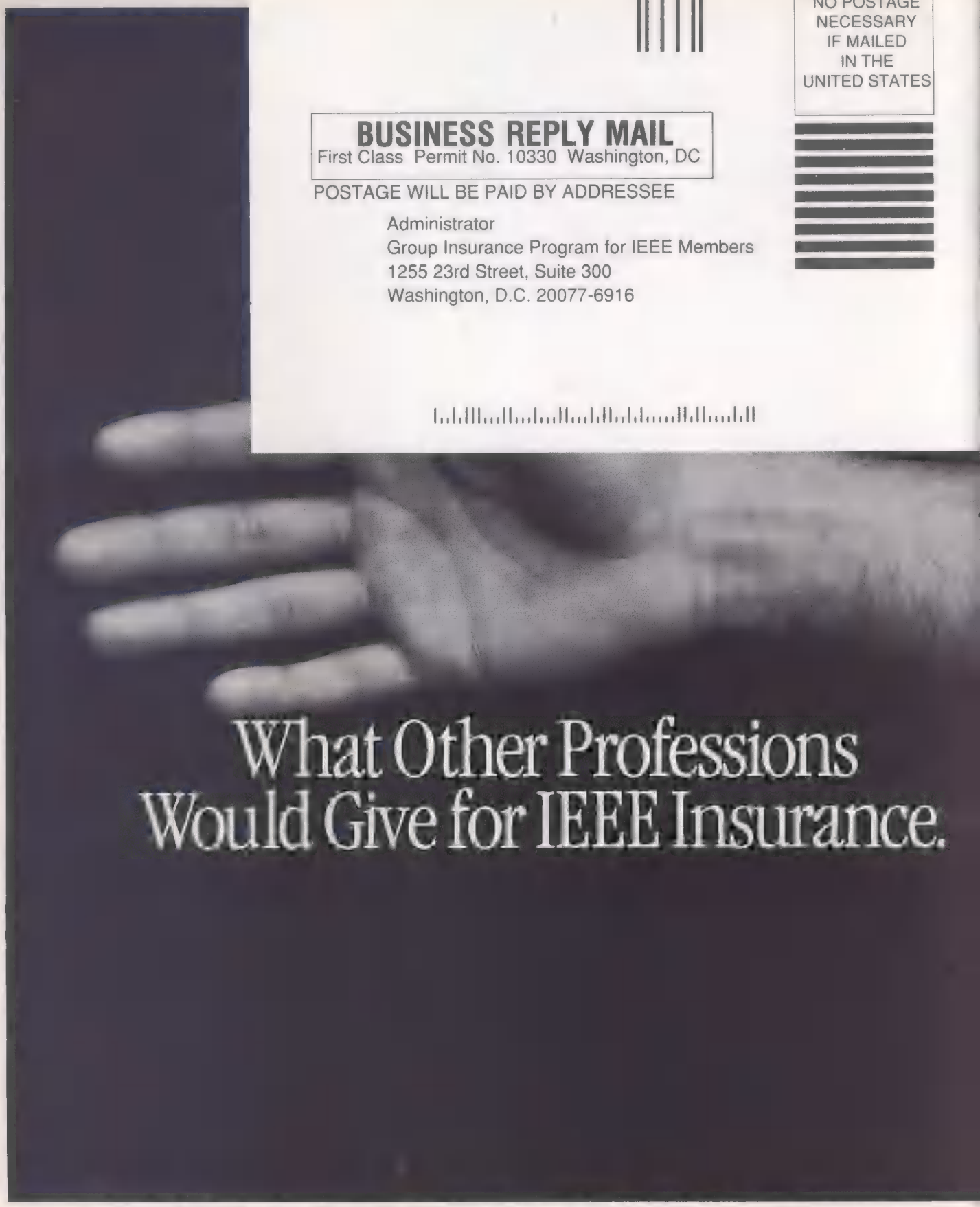
IEEE INSURANCE
Designed by Engineers.
For Engineers.

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
First Class Permit No. 10330 Washington, DC

POSTAGE WILL BE PAID BY ADDRESSEE

Administrator
Group Insurance Program for IEEE Members
1255 23rd Street, Suite 300
Washington, D.C. 20077-6916



What Other Professions Would Give for IEEE Insurance.

Your Association used group purchasing power to negotiate top quality insurance for members—at a very low price. We designed this coverage specifically for your professional needs.

Most plans cover the whole family and, as long as you remain a member of the Association, stay in effect no matter how often you change jobs. Your personal policy can even be

tailored to suit your changing circumstances.

No wonder other professions would give their right arm for our insurance. Find out more about this benefit by calling 1-800-424-9883 (in Washington, D.C. call 457-6820).

IEEE INSURANCE
Designed by Engineers.
For Engineers.

(Continued from p. 16)

"likely" or "unlikely" are totally ambiguous in such circumstances. Hence, we chose the quantitative language we did.

By "significant health risk" we mean a risk to which public health authorities would deem it appropriate to devote attention and resources.

We have not had resources to conduct a systematic elicitation of experts' subjective judgments. We *have* had regular informal discussions with a wide variety of scientists working in this field and on several occasions have asked them explicitly to assess odds. Several colleagues report to us that they have done the same. Most of these experts are members of the Bioelectromagnetic Society. Some are researchers supported by the Electric Power Research Institute (EPRI) or the Department of Energy. Some are utility, EPRI, public health, or other technically oriented administrators. In our informal discussions, we see a continuum of opinions. The center of mass is probably toward the lower end of the range we quoted. We know a few people who would assess odds of 0 percent and of 100 percent, but our experience is that such people are the exception.

On Desoer's second point, epidemiological studies of association between field exposure and cancer have been done in Sweden and the United Kingdom. Results from these were included in the summary figure in Part 1, p. 25, of our study.

The Swedish study of childhood cancer deaths is most comparable to the Denver study. Both yielded relative risks of about 1. We are unaware of completed studies from the other countries Desoer asks about.

Paying for R&D

Your excellent special issue "R&D: Managing to be competitive" [October] on redirecting Federal R&D facilities to new purposes arrived the same day as *Business Week*, which printed a letter stating that DuPont is following developments on superconductivity at Federal laboratories with an eye toward technology transfer.

The Federal R&D facilities have played their part since World War II. Now, let us take note of the fact that these facilities are tying up large numbers of engineers and scientists, who are in short supply, and are costing billions of dollars.

Let us keep a solid space program and a prudent weapons program, and let us shut the rest down.

The peace dividend should go to citizen taxpayers. DuPont can pay for its own R&D program.

Robert Barry
Monroeville, Pa.

Scanning the X-rays

If it were not for the short curriculum vitae at the end of "A digital prescription for X-ray overload" by William J. Dallas [April, p. 33], I would never have guessed the author had any connection with the real health service. Technically the article was superb—it's a pity that the remainder let it down.

To begin with, Dallas has a hard product to compete with. The X-ray film is a very high-resolution, highly portable source of information requiring no special viewing facilities.

Dallas commences with a scenario of a major trauma accident. His demeaning opinion of the skill of technicians may be appropriate in the United States, but in New Zealand, where the standard is extremely high, these comments would be treated with contempt.

As for "rushing wet X-rays," if the hospital is so poorly equipped that it does not use automatic processing, then it would be a reasonable assumption to say that it was poorly equipped in other ways and should not be attending to the patient initially. The wet film concept is as out of date as the gas lamp.

All the automatic digital equipment in the world cannot replace the human skill, care, and understanding implicit in the task of the radiographer in aligning the X-ray beam and the image receptor (be it film, image intensifier, or whatever) in the correct anatomical relationship on a distressed, traumatized patient.

Dallas refers to the possible "elimination of retakes" by the use of a digital system. This is completely illusory, for it assumes that the retakes are the result of exposure alone. In most cases, a radiographer "retakes" a film for reasons other than exposure, such as patient positioning or patient movement. Automatic exposure devices are generally not used in the trauma/operating room.

In displaying the image, few radiologists would be prepared to give a diagnosis from a CRT with fewer than 2028 pixels. Until high-resolution display systems are so readily available and cheap as to be standard issue, then image reproduction this way is a nonstarter.

Further, the concept of using one screen to display in sequence a series of images is also unacceptable. A radiologist needs to be able to compare images side by side and, when teaching, to compare films of different patients taken at different times. How easily is this achieved using one screen alone?

In conclusion, Dallas' article is of value for what it is—an insight into digital imaging. However, the scenario depicted is so biased to accentuate the merits of the system that it loses sight of reality.

Ian Thompson
Palmerston North, New Zealand

The author responds:

I agree that the digital picture archiving and communications systems have a hard product to compete with. But just as the computer-based hospital information systems have begun to replace the reams of paper generated in the front offices of the hospitals, so will the film be replaced by computer-based systems.

I strongly disagree with Thompson's characterization of my opinion of the skilled technician as demeaning. The technicians perform a difficult task that, with the present equipment, cannot be done perfectly. There are retakes! Portable X-ray units do not have the sophistication and automation of fixed-place units.

To the comment on rushing about with wet X-rays, the present-day standard terminology for these types of readings, that is, for films that have been taken and are physically transported to a radiology department for a quick reading, is "wet reading." Of course the films are processed in an automatic processing machine. The scenario is not out of date. In most of the major hospitals at the present time, there are immediate readings that have to be done.

In the paragraph dealing with the difficulties in taking X-ray films, I made no reference to aligning X-ray beams or image receptors. I am in complete agreement with Thompson that it will be many years, if ever, before humans are replaced. My reference to elimination of retakes is real. In our hospital, we have found that in difficult cases or cases where the radiation dose is critical, using computed radiography with its much greater latitude than conventional film does eliminate almost all the retakes. There will, of course, be some cases where retakes are done for other reasons, but the majority of problems are in the exposure.

Thompson also makes a very good point that automatic exposure devices used to control exposures on static equipment are generally not used in the trauma/operating room situation. He is absolutely right. This makes the exposure task that much more difficult.

He makes the point that few radiologists would be prepared to give a diagnosis from a CRT with fewer than 2028 pixels. (A small point—the numbers are usually powers of two. That would be 2048.) At the present time, few radiologists are prepared to give diagnoses from any CRT, regardless of the resolution. There is a great deal of work that must be invested in determining whether the diagnoses made from CRT readings are as accurate as the corresponding readings from film.

I also agree that systems with just one CRT are probably not going to be accepted for diagnostic reading. Whether the systems will have two, three, four . . . screens is a question that has not been answered at this time. The favorite numbers are 2, 4, 6, and 8.

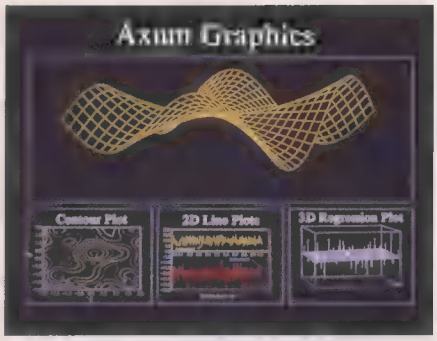
Corrections

On p. 59 of the October issue, it was stated that ". . . the Arthur D. Little consulting firm pioneered the contract research business, though the Cambridge, Mass.–based company has always been for-profit and most of its business is now management consulting." This statement may have given readers the impression that the firm does very little technology and product development today. On the contrary, 35 percent of the company's revenues come from technology and product development.

On p. 80, left column, the firm from which Siemens acquired a Rolm division should have been given as IBM Corp.

On p. 5 of the November issue, the cover illustration should have been credited to Marc Ericksen of Marc Ericksen Illustration, San Francisco, who used an airbrush in creating the artwork. —*Ed.*

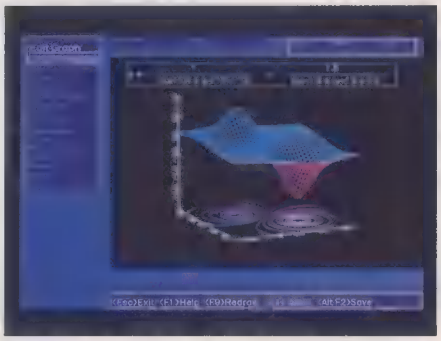
Amazing Graphics Made Simple



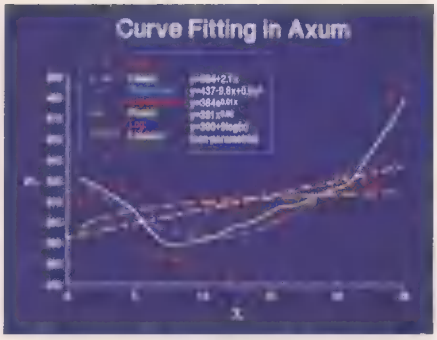
Create publication-quality, full color graphics

"Axum brings the ease of use of business graphics software to the more technical world of the engineer and scientist."

PC Magazine



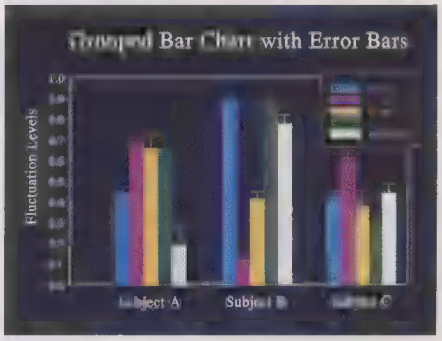
Rotate 3D objects interactively



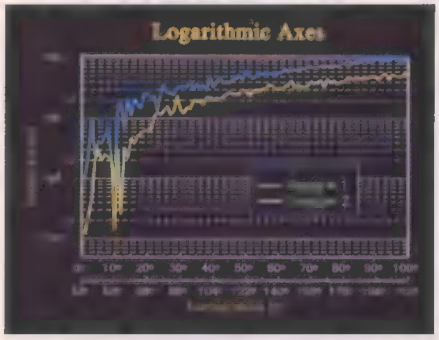
Do curve fitting, smoothing, and statistics

Publication-quality graphics

- 2D, 3D, Contour, Polar, Smith and more
- 21 fonts, scientific, super and subscripts
- Interactively create and customize
- Plot arbitrary 2D and 3D functions
- Create analytical drawings
- Use dual y axes, log axes, and floating axes
- Features ultra-high resolution output from GraphiC™ by Scientific Endeavors



Compatible with WordPerfect®, Word®, Ventura®, PageMaker®

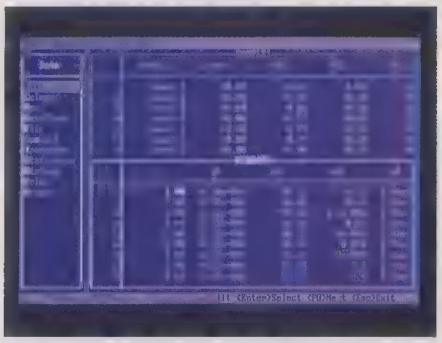


"Axum is to computer graphing what one of the major word processors is to text handling. Axum does just about everything one would ever want to do, and maybe a bit more."

review in Materials Research Bulletin

State-of-the-art data editor

- Import, edit, and transform data
- Use unlimited-sized data sets
- Choose from over 100 functions and operators for transforming and manipulating data
- Create macros using Axum's built-in, advanced programming language
- Import Lotus®, dBase®, and ASCII data
- Supports dozens of printers and plotters
- IBM PC/XT/AT/PS2 & compatibles



"Excellent product which I have recommended to hundreds of our short course participants from hundreds of companies."

Michael VanDeMark, Chemist
University of Missouri

Call today for a FREE brochure

60 Day Money Back Guarantee

1-800-548-5653 ext. 421

Axum™ Technical Graphics and Data Analysis

TRIMETRIX

444 NE Ravenna Blvd
Suite 210-PA
Seattle WA 98115
206-527-1801
FAX 206-522-9159

Circle No. 31

Big display is all done with mirrors

An ultraminiature "virtual" display that produces an image much larger than the display itself was offered as a commercial product for the first time this year by Reflection Technology in Waltham, Mass. When held near the eye or mounted on a headset, the virtual screen lets people work hands-free and move around unencumbered by a stationary display, to view information from portable or remote electronic products. Trademarked the Private Eye, the display is expected to bring the information content and clarity of desktop screens to full-function pocket PCs, full-screen radio pagers, pocket fax receivers, and even toys and games.

The display is housed in a battery-powered package measuring 3 by 3.3 by 8.9 centimeters (1.2 by 1.3 by 3.5 inches). Users looking into a 3-cm window see a black field on which there appears to float a vibrant red image with the resolution and readability of a display with a 30-cm (12-in.) diagonal. The Private Eye displays 720 by 280 pixels that can be either used for graphics or formatted as 25 lines of text with 80 characters per line.

Although other inventors have tried to devise such portable, miniature virtual displays, two practical problems stymied them: achieving high resolution in a small space, and running the system on reasonably low power. Reflection Technology's president Allen Becker does both by combining a number of existing technologies in a unique manner.

Instead of creating a full two-dimensional display matrix, which would not produce high enough resolution or yield, Becker simulated a two-dimensional image by setting up a vertical column of 280 light-emitting diodes (LEDs) and imaging it with a horizontally scanning mirror. The mirror, hinged along one edge, is driven by an electromagnet attached to its back. By turning the LED column on and off rapidly, showing one column of dots at a time, and moving the mirror to spread an array of single columns across a full-screen image, Becker succeeded in his objective of creating a full-screen virtual display.

In order to present a stable image to the viewer, the Private Eye synchronizes the LED column's output with the mirror's movement. A photodetector sensor is mounted to the case behind the mirror. A tab mounted to the back of the mirror interrupts the photosensor light beam circuit as the mirror oscillates in simple harmonic motion. By thus timing the movement of the mirror, the photosensor signal determines the proper timing for each LED column of the screen.

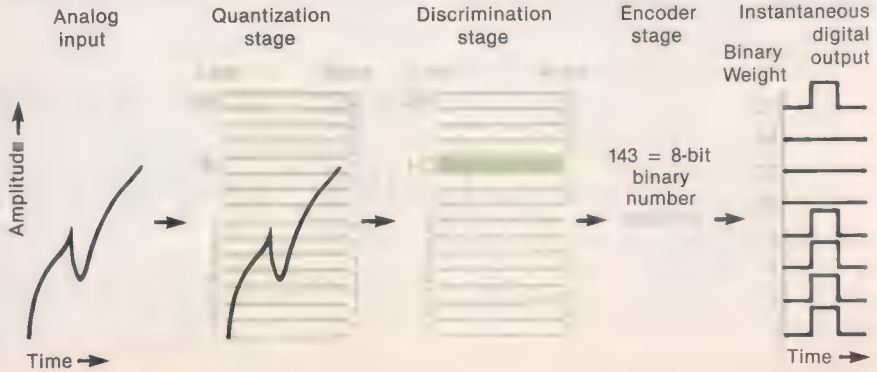
In addition, as the photosensor indicates that the mirror is at the center of its arc, a small voice coil (similar to an audio speaker) mounted behind the mirror pushes against a magnetic spring-mounted counterweight that is set opposite to the mirror. The resonant frequency of the counterweight system is the same as the mirror's, so essentially the entire mirror/counterweight/coil mechanism acts like a tuning fork, absorbing the preponderance of the vibration that is created by the resonating mirror.

In addition, monitoring the mirror's movement makes it possible to apply power at just the right moment to maintain the amplitude of the motion. Like pushing a child on a swing, the vibration can be maintained at its natural frequency with just a small push applied at the center of every arc. Only 0.01 watt is needed to keep it moving.

The image owes its high quality to another technique: the 280 LEDs, instead of being lined up in one vertical column, are staggered left and right; the two sides of the staggered LED column are illuminated at slightly different times to allow the mirror's movement to combine the images of the left and right sides. The pixels appear to touch each other, top to bottom, creating a solid field without the blank interrupt lines that are normally seen on a CRT screen between successive scanned lines.

A lens mounted on a sliding track between the mirror and the LED array magnifies the image. By adjusting the optics, the user can place the image plane at eye distances anywhere between 15 cm (9 in.) and infinity. An image can therefore be located on the same plane as other objects in the user's field of view.

Another model of the Private Eye works with a standard PC by plugging in the included interface card. The PC Private Eye is IBM Color Graphics Adapter (CGA) compatible. It includes a Private Eye display,



headset, an IBM PC-compatible half-size video adapter board, and a 1.8-meter cable. It sells for US $499 from PC Connection Inc., Marlow, N.H.

Look, ma, no clock!

A chip that converts an analog voltage to a digital signal in near real time—typically 20 nanoseconds—was awarded U.S. patent 4 954 831 on Sept. 4, 1990. According to inventor Robin K. Elkins, president of R-K Manufacturing Co., Hollywood, Fla., the new analog-to-digital (A/D) converter should prove useful in all applications, including military communications and other high-frequency tasks (50 megahertz and above) where traditional A/D converters are sluggish or not useful at all.

Traditional A/D converters use an external clock to sample an analog signal at a regular interval (typically from once every two seconds to 40 000 times per second), compare that to a reference voltage, and output the result digitally after encoding. Because of all the tasks performed, typical propagation time through the device is 25 microseconds or more, making such A/D converters of limited use at frequencies above 20–40 kilohertz.

Elkins avoids that complexity and time delay by devising an A/D converter of extreme simplicity and reliability, whose output is produced with no external clock and no processing. According to the patent, the simplicity of the design makes it virtually error-free.

Digitization is achieved in three stages [see illustration on the opposite page]. First, a quantization or threshold-detector stage receives the analog input and determines which of a series of successively higher threshold voltages it exceeds. This stage has a separate output terminal for each threshold value. Every output terminal whose threshold value is exceeded will be altered, while remaining terminals retain their opposite binary logic state.

Second, a discriminator stage—which has the same number of output terminals as the quantization stage—selects only the highest valued output terminal of the quantization stage. This highest value alone activates an identifying binary logic state of the discriminator stage, leaving all the other output terminals in the opposite binary logic state.

Third, an encoder takes the output of the discriminator stage and weights it to yield a binary number, which is output as the digital value corresponding to the instantaneous magnitude of the analog input signal.

The patented design can be scaled up to virtually any number of bits of resolution, he said. In addition, the unit can be custom-tailored so that a user can "dial in" any mathematical input function (such as a logarithmic amplification, 2:1 compression, and the like) to calibrate it for specific applications.

Elkins has commercially manufactured A/D converter chips with 8-bit resolution (256 levels) between 0 and +5 volts; the product is designated the ADC 808E and can be purchased for US $85 each in production quantities.

Coordinator: Trudy E. Bell
Consultants: Ralph H. Baer and Homer Jensen

Back to the classrooms

One engineer for every U.S. school—elementary and secondary—is the goal of the Engineering Societies' Task Force on Pre-College Math and Science Education. The idea is for 100,000 highly qualified volunteers to advise the schools on how to improve math and science education.

Some 25 engineering and engineering-related societies, including the IEEE, support the task force. Together, they represent more than 1 million U.S. engineers. *Contact: the American Association of Engineering Societies, 1111 19th St., N.W., Suite 608, Washington, D.C. 20036-3690; 202-296-2237; fax, 202-296-1151.*

Let employers beware

Claims to credentials and degrees are proving fraudulent in the case of many requests to verify them being received by colleges and universities throughout the United States, according to Kathryn Robens, associate director of admissions and records, San Diego State University, California. Writing in the October 1990 *Bulletin* of the IEEE San Diego Section, Robens cautions that employers considering a job applicant should ask for an official transcript mailed from the institution. Unofficial records from the applicant should not be accepted.

Most institutions do not require an applicant's signature to release information just to verify that degrees have been earned; a phone call or letter will suffice. The American Association of Collegiate Registrars and Admissions Officers has a pamphlet on the subject, *"Misrepresentation in the Market Place."* Cost is US $4 from Aacrao, 1 Dupont Circle, N.W., Washington, D.C. 20036.

Engineering your future

Anyone concerned about the direction his or her career is or is not taking might want to look at *Moving Up*, a career-development videotape designed for engineers. The tape provides a framework for career assessment.

It starts by helping viewers create their own definition of success. For some, success means moving up in the hierarchy. Others define it as more freedom to decide what to do and how to do it—or as gaining assignments with more challenge and excitement—or the ability to make a real impact on one's profession or organization—or achieving a balance among work, home, and other interests. Whatever the definition, the program then focuses on the steps needed to reach that level of success.

Much of the material in *Moving Up* is culled from the experience of successful senior engineers, according to the developer of the videotape, the American Society of Mechanical Engineers. The program is designed to be directed by an experienced engineer or human resources manager working with groups of 5–20 engineers. It relies on workbook exercises and group discussions and can be either completed in one five-hour session or divided into segments of an hour or two.

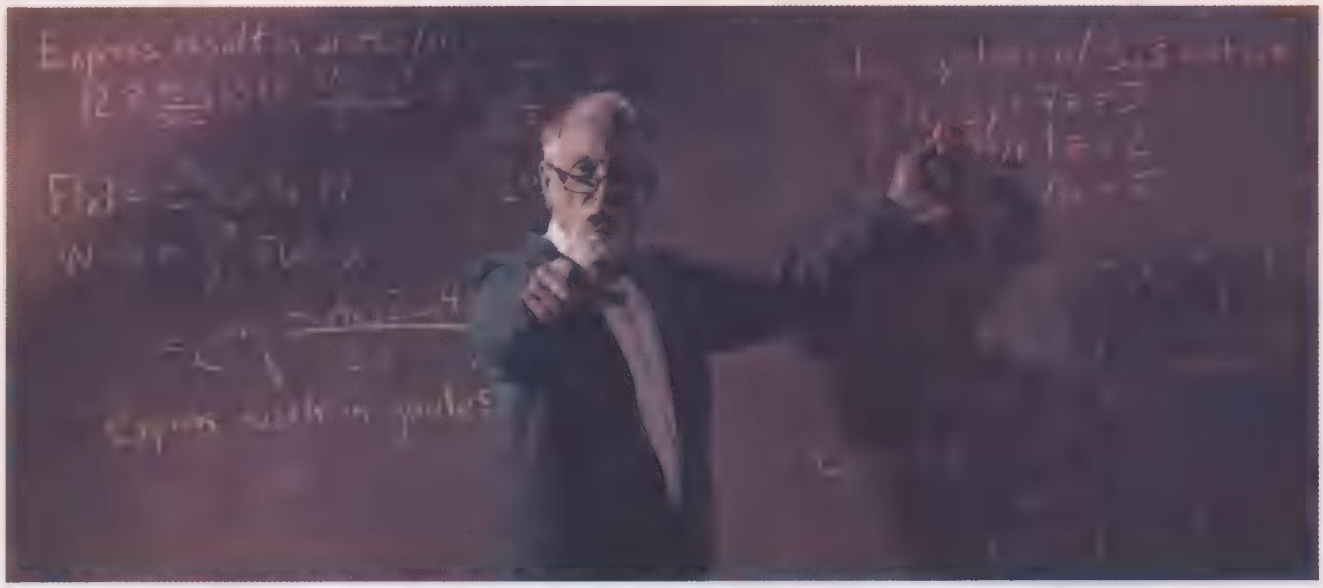
Price of the program, including the videotape, facilitator's guide, and 10 participants' workbooks is US $325 plus US $18.50 for handling. Bulk discounts are available. *Contact: American Society of Mechanical Engineers, Order Department, 22 Law Dr., Box 2300, Fairfield, N.J. 07007-2300; 1-800-843-2763.*

Poles no longer apart

Polish students will soon be entering the Ph.D. program run by the Electrical and Computer Engineering Department at Carnegie Mellon University in Pittsburgh, now

(Continued on p. 28)

In college, you would have killed for MathCAD. So why aren't you calculating with it now?



100,000 engineers and scientists already let MathCAD do their calculations for them.

Now that college is far behind you, perhaps it's time you graduated from spreadsheets, calculators and programming.

Because in today's working world of engineering and science, there's no time for anything less than MathCAD. The software that lets you perform engineering and scientific calculations in a way that's faster, more natural, and less error-prone than any calculator, spreadsheet, or program you could write yourself.

Thanks to MathCAD's live document interface,™ you can enter equations anywhere on the screen, add text to support your work, and graph the results.

PC MAGAZINE EDITOR'S CHOICE
March 14, 1989 issue.
Best of '88
Best of '87

It also comes complete with over 120 commonly used functions built right in. Perfect for creating complex equations and formulas, as well as exponentials, differentials, cubic splines, FFTs and matrices.

You get three-dimensional plotting, vivid graphing, and the ability to import HPGL files from most popular CAD programs, including AutoCAD®.

Done calculating? MathCAD prints *all* your analyses in presentation-quality documents, even on PostScript® printers.

All of which has made MathCAD far and away the best-selling math software in the world. In fact, it's used by over 100,000 engineers and scientists—including 31,000 electrical engineers just like you.

There's MathCAD for the PC. MathCAD for the Mac, written to take full advantage of the Macintosh® interface. And a Unix® version that utilizes the speed and unlimited memory of your Unix workstation.

We also have Applications Packs for Advanced Math, Statistics, Mechanical, Chemical, and Electrical Engineering. Each is a collection of adaptable mathematical models, designed to let you start solving your real world problems right away.

For a free MathCAD demo disk, or upgrade information, dial 1-800-MATHCAD (in MA, 617-577-1017). Or see your software dealer.

Available for IBM® compatibles, Macintosh computers, and Unix workstations.

TM and ® signify manufacturer's trademark or registered trademark, respectively.

1-800-MATHCAD

MathCAD 2.5 includes 3-D plotting, HPGL sketch import, and PostScript output.

MathCAD®

MathSoft, Inc., 201 Broadway, Cambridge, MA 02139

U.K.: Adept Scientific 0462-480055; France: ISECEGOS 1-46092768; Germany: Softline 07802-4036; Japan: CRC 03-665-9762; Finland: Zenex Oy 90-692-7677; Italy: Channel 02-4229441. *PEE*

Circle No. 6

(Continued from p. 26)
that it has signed an agreement with the Electronics Department of the Technical University of Warsaw to consider the latter's top students as applicants. The students will be accepted with the proviso that they return to Poland when they complete their education.

"While they may lack experience with up-to-date computer technologies, they have excellent backgrounds in mathematics and represent a considerable new source of raw talent," said Stephen W. Director, head of the department.

He added that the educational crisis in math and science evident in U.S. high schools is moving into its universities. "With the number of high-quality graduate students declining in the United States, Eastern Europe is another place to look for outstanding students," he said.

Who's who in semi research

If you want to know who's doing what in semiconductor research in the United States, send for *1990 SRC U.S. Faculty Source Book*, recently compiled by the Semiconductor Research Corp. of Research Triangle Park, N.C. It contains information on more than 800 faculty members engaged in semiconductor research at 102 U.S. colleges and universities.

Edited by Jon D. Bender, a technical policy analyst for the semiconductor consortium, the 420-page directory was put together to facilitate communications within the semiconductor research community and, in the long run, avoid duplication of effort. The book identifies researchers within specific areas of IC technology, and assesses the size and distribution of projects within semiconductor research.

The book sells for US $41 (including postage and handling in the United States). *Contact: Higher Education Publications Inc., 6400 Arlington Blvd., Suite 648, Falls Church, Va. 22042; 703-532-2300; fax, 703-532-2305.*

Working abroad

University-level engineering students who want to work abroad can apply to the International Association for the Exchange of Students for Technical Experience (IAESTE) in any of 52 countries belonging to the program. The trainees must be at the third year level or above. They pay their travel expenses, while their employers pay a program fee and training stipend.

In the United States, arrangements are handled for both U.S. employers seeking foreign interns and U.S. students seeking to work abroad by the Association for International Practical Training (AIPT). Assignments last between 2 and 18 months.

For next summer, the deadline for U.S. employers to file applications with AIPT for trainees is Jan. 10; the deadline for U.S. students to apply for work abroad is Dec. 10. That last date probably comes too soon for most people to apply for placement in next summer's program. However, late applications may be considered for subsequent programs.

In the United States, contact Edson Bishop, Director, Student Exchanges/IAESTE, 10400 Little Patuxent Parkway, Suite 250/SM, Columbia, Md. 21044-3510; 301-997-3069. Outside the United States, contact the IAESTE organization in your country.

Quality is the issue

The newly elected chairman for 1991 of the American Electronics Association urged every one of its member companies to apply for a Malcolm Baldrige National Quality Award. "Even if the companies are too small to meet the criteria for applying," said Motorola president Gary L. Tooker, "the process of evaluating [the] companies' performance, goals and objectives against the award criteria will improve their competitiveness."

The quality of products and services in the electronics industry is the most important near-term issue to be addressed, he continued, and expectation levels of any company's customers are increasing daily. Tooker would like to see the electronics association take the lead in helping its member companies meet those expectations.

Coordinator: Alfred Rosenblatt
Coordinator: Mary Golladay, National Science Foundation

MATLAB™

High-Performance Numeric Computation and Data Analysis

MATLAB has rapidly become an industry standard for engineering and scientific research. Its unique interactive interface, algorithmic foundation, easy extensibility, and speed make MATLAB the software system of choice for ***high productivity and high creativity*** research.

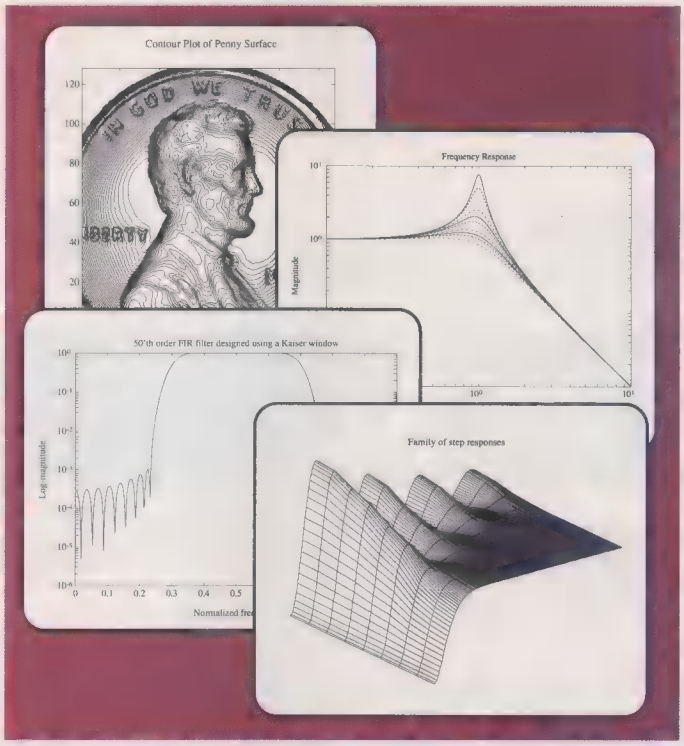
Problems and solutions are expressed just as they are written mathematically — ***without the need for traditional programming***. As a result, you can solve numerical problems in a fraction of the time required to write a program in Fortran, Basic, or C. Then plot the results as 2-D and 3-D graphics, with publication-quality output to plotters, dot-matrix printers, and laser printers.

"I can create algorithms so easily that it almost seems like cheating."

Personal Engineering & Instrumentation News

Add to MATLAB your choice of tools for digital signal processing, system identification, control system design, and more. MATLAB's open-system design lets you see the algorithms and the implementations, even change them to suit your specific requirements.

MATLAB is developed by The MathWorks, a leader in software for data analysis and mathematics. Our users — in thousands of companies and universities — know that MATLAB enables them to work more creatively and productively. Take a look at how MATLAB can do the same for you.



"MATLAB is the undisputed choice for computation-intensive engineering work."

Macworld

"MATLAB's power and ease of use go a long way toward taking the drudgery out of repetitive analysis projects."

IEEE Spectrum

Over 300 Built-In Functions

- eigenvalues
- matrix arithmetic
- matrix decompositions
- convolution
- spectrum estimation
- complex arithmetic
- 1-D and 2-D FFTs
- filtering
- curve fitting
- cubic splines
- Bessel functions
- elliptic functions
- nonlinear optimization
- linear equation solving
- differential equations
- polynomial arithmetic
- descriptive statistics
- 2-D and 3-D graphics

Plus Toolboxes for:

- digital signal processing
- parametric modelling
- control system design
- chemometric analysis, and more

Computers supported

PCs and ATs
386-based PCs
Macintosh
Sun
Apollo
HP 9000/300
DEC Station
VAX/VMS
VAX/Ultrix
Stardent
Convex
Encore
Alliant
Cray
and more

To find out more about MATLAB, call us at **(508) 653-1415**. Or simply return the completed coupon to the address below.

Name _____

Company _____

Department _____

Address _____

City, State _____

Zip _____ *Country* _____

Telephone _____

Computer(s) _____

The MATH WORKS Inc.

21 Eliot Street
South Natick, MA 01760
Phone: (508) 653-1415
Fax: (508) 653-2997

SP 12/90

Circle No. 28

(Continued from p. 8)

MARCH

Fifth International Workshop on High-Level Synthesis-HLSW (COMP et al.); March 3-6; Bülerhohe, Germany; Raul Campusano, IBM Thomas J. Watson Research Center, Box 218, Yorktown Heights, New York 10598; 914-945-3871.

Electronics and Instrumentation Conference and Exhibit (ISA/IEEE); March 6-7; Cincinnati Convention Center, Cincinnati, Ohio; Orest M. Melnyk, IEEE, Box 15044, Cincinnati, Ohio 45215; 513-397-1044.

Applied Power Electronics Conference and Exposition-APECT '91 (PEL); March 11-15; Hyatt Regency Dallas Hotel, Dallas, Texas; Ann Beightol, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

International Conference on Microelectronic Test Structures (ED); March 18-20; Kyoto Grand Hotel, Kyoto, Japan; Noriaki Nakayama, (81+462) 48 3111, ext. 3730.

European Workshop on Refractory Metals and Silicides (ED); March 24-27; Sweden; S. Petersson, (46+8) 752 1401.

International Conference Control '91 (UKRI Section); March 25-28; Edinburgh Conference Centre, Heriot-Watt University, Edinburgh, Scotland; Louise Bousfield, IEE Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England; (44+1) 240 1871; fax, (44+1) 240 7735.

APRIL

Second International Symposium on Integrated Network Management (IFIP et al.); April 1-5; Crystal Gateway Marriott, Washington, D.C.; Action Motivation, Box 191885, San Francisco, Calif. 94119; 415-392-3751.

Southeastcon '91 (Region 3 et al.); April 7-10; Fort McGruder Inn, Williamsburg, Va.; Griffith G. McRee, 525 Virginia Deare Dr., Virginia Beach, Va. 23451; 804-683-4897 (O) or 804-428-0083 (H).

Infocom '91 (C, COMM); April 7-11; Sheraton Bar Harbour, Bar Harbour, Fla.; Ken Joseph, Bell Canada, 160 Elgin St., Ottawa, Ont. K1G 3J4, Canada; 613-781-7214; fax, 613-234-1442.

First International Workshop on Interoperability in Multidatabase Systems (CO); April 8-9; Kyoto University, Kyoto, Japan; IEEE Computer Society Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Third International Conference on Indium Phosphide and Related Materials (ED); April 8-10; Park Hotel, Cardiff, Wales, UK; Robert Wangemann, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 201-562-3895.

International Reliability Physics Symposium (ED, R); April 8-11; Caesars Palace, Las Vegas, Nev.; Alfred L. Tamburrino, RADC/ RBRP, Griffiss AFB, N.Y. 13441-5700; 315-330-2813.

Ninth Annual IEEE VLSI Test Symposium (COMP et al.); April 16-18; Bally's Park Place Casino Hotel, Atlantic City, N.J.; William Zacker, 40 Gill Lane, Woodbridge, N.J. 07095; 201-636-8616.

International Symposium on Power Semiconductor Devices (ED); April 22-24; Baltimore, Md; M. Ayman Shibib, AT&T Bell Laboratories, 2525 N. 12th St., Reading, Pa. 19612; 215-939-6576.

10th International Symposium on Computer Hardware Description Languages and their Applications (IFIP et al.); April 22-24, Marseille, France; Ronald Waxman, Department of Electrical Engineering, Thorton Hall, University of Virginia, Charlottesville, Va. 22903-2442; 804-924-6086.

Third International Symposium on Power Semiconductor Devices and ICs (ED/IEE); April 22-24; Stouffer Harborplace Hotel, Baltimore, Md.; M. Ayman Shibib, AT&T, 2525 N. 12th St., Reading, Pa. 19612-3566; 215-939-6576.

International Symposium on Subscriber Loops and Services-ISSLS '91 (COMM et al.); April 22-25; Raicongrescentrum Europaplein, Amsterdam, The Netherlands; Paul 't Hoen, PTT Netherlands, Box 39, 2260 AA Leidsehenam, The Netherlands; (31+70) 43 22 33; fax, (31+70) 43 21 40.

(Continued on p. 28D)

LOCATION AND LOGISTICS
INDUSTRIAL INFRASTRUCTURE
WORKFORCE

Transship goods from Holland at the lowest cost in Europe, without spinning wheels

Holland remains the strategic Gateway to Europe—and not just because of her ideal location.

Her concentrated network of road, water, rail and air transportation helps companies transship quickly and economically to all major European markets and worldwide.

Over 30% of all EC imports are brought in through Dutch ports and airports, including Rotterdam and Schiphol. Dutch haulers account for over 25% of cross-border EC road transport.

Almost half of Holland's GDP is exported, so it is no wonder the Netherlands has developed an unparalleled system of distribution facilities and logistical assets—including about 2,500 bonded and FEMAC warehouses, 24-hour customs stations, teleports and computerized cargo tracking systems that reduce transit times and costs.

Working with Dutch masters at freight forwarding and product distribution is an easy way to get started in Europe.

After, you may join the 1,500 North American companies that already have invested in Holland, establishing European headquarters or sales, repair and service, assembly, manufacturing or R&D centers.

Netherlands Foreign Investment Agency

NEW YORK (212) 246-1434 • SAN FRANCISCO (415) 981-1468 • LOS ANGELES (213) 477-8288 • OTTAWA (613) 237-5030

IEEE

Please send me literature on *The Netherlands: Europe's Gateway to 1992.*

Complete this coupon and mail it to: Mr. Irwin de Jong, Executive Director
Netherlands Foreign Investment Agency, One Rockefeller Plaza, New York, NY 10020.

Name _____ Title _____

Company _____ Telephone _____

Address _____

City _____ State _____ Zip _____

HIT THE GROUND RUNNING

Circle No. 25

CALENDAR

(Continued from p. 28B)

International Workshop: Quality of Telecommunications Services and Products (IEEE QAMC); April 23-25; Val David, Canada; V. Seshadri, Room 3J536, AT&T, Crawfords Corner Road, Holmdel, N.J. 07733.

MAY

IEEE/IAS Industrial and Commercial Power Systems Conference-I&CPS '91 (IA); May 6-9; Hilton Inn, Memphis, Tenn.; Allan H. Long, Memphis Light, Gas & Water Division, Box 430, Memphis, Tenn. 38101-0430; 901-528-4859.

Compeuro '91-IEEE Fifth International Conference on Advanced Computer Technologies, Systems, and Applications (COMP et al.); May 7-10; Bologna, Italy; V. A. Monaco, Dip. Elettronica, Informatica e Systemistica, University of Bologna, Viale Risorgimento 2, 1-40136, Bologna, Italy.

Power Industry Computer Applications Conference-PICA '91 (PE); May 7-10; Hyatt Regency/ Sheraton, Baltimore, Md.; William Keagle Jr., Baltimore Gas & Electric Co., Electric Test Facility-RBC, Box 1475, Baltimore, Md. 21203; 301-281-3788.

IEEE Pacific Rim Conference on Communications Computers and Signal Processing (Victoria Section), May 9-10; Dr. Pan Agathoklis, Department of Electrical and Computer Engineering, University of Victoria, Box 3055, Victoria, B.C., Canada V8W 3P6; 604-721-8618.

Custom Integrated Circuits Conference (ED); May 12-15; Town and Country Hotel, San Diego, Calif.; Laura Morihara, Convention Coordinating, 298 Ohina Place, Kihei, Maui, Hawaii 96753; or Roberta Kaspar, 1597 Ridge Rd. W., Suite 101C, Rochester, N.Y. 14615; 716-865-7164; fax, 716-865-2639.

Ideas in Science and Electronics Symposium and Exposition (IEEE Albuquerque et al.); May 14-16; Albuquerque Convention Center, Albuquerque, N.M.; Dave Smoker Communications, 218 Manzano N.E., Albuquerque, N.M. 87108; 505-266-7292; or Charles E. Christmann, 505-262-1023.

Vehicular Technology Conference (VT et al.); May 19-22; Sheridan West Port Inns, Maryland Heights, Mo.; Jay Underdown, 58 Judy Dr., St. Charles, Mo. 63301; 314-946-9980 (O); 314-723-4200 (H).

Second Physical Design Workshop (ACM/ SIGDA); May 20-22; Pittsburgh; Mary Jane Irwin, Pennsylvania State University, University Park, Pa. 16802; 814-865-1802.

National Aerospace and Electronics Conference-NAECON '91 (AES et al.); May 20-24; Dayton Convention Center, Dayton, Ohio; Sue Brown, ASD/ ENES, Wright-Patterson AFB, Ohio 45433-6503; 513-255-6281.

Annual IEEE/ASME Joint Railroad Conference (IEEE et al.); May 21-23; St. Louis, Mo.; Robert B. Fisher, Land Transportation Division, Southeastern Pennsylvania Transportation Authority, 5800 Bustleton Ave., Philadelphia, Pa. 19149; 215-580-4888.

International Symposium on VLSI Technology, Systems, and Applications (ED); May 22-24; Lai Lai Sheraton Hotel, Taipei, Taiwan; Alice Chiang, 617-981-4629.

Mediterranean Electrotechnical Conference (Region 8); May 22-24; Ljubljana, Yugoslavia; Baldomir Zajc, Fakuteta za Elektrotehniko, Trzaska 25, 61000 Ljubljana, Yugoslavia.

JUNE

Fourth International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems (COMP et al.); June 2-5; Waiohai Hotel, Kauai, Hawaii; Moonis Ali, University of Tennessee Space Institute, MS15, B.H. Goethert Parkway, Tullahoma, Tenn. 37388; 615-455-0631, ext. 236; fax, 615-454-2354.

IEEE Pulp and Paper Industry Conference (IA); June 3-7; Hotel des Gouverneurs Lerand, Montreal; Michael Riverin, Relcon Inc., 2535 Cavendish Blvd., Montreal, Que., Canada; 514-487-6111.

Intensive Course on Electrical Contacts (IEEE/ CHMT); June 3-7; Radisson Plaza Raleigh, Raleigh, N.C.; IEEE Holm Conference Registrar,

(Continued on p. 28F)

(Continued from p. 28D)

445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3863, fax, 908-562-1571.

International Microwave Symposium-MTT '91 (MTT); June 11-13; Hynes Convention Center, Boston; Peter Staecker, MA-COM, 52 South Ave., M/S 704, Burlington, Mass. 01803; 617-272-3000, ext. 1602.

Device Research Conference (ED); June 16-19; University of Colorado, Boulder; Larry Coldren, University of California, Department of Electrical Engineering and Computer Engineering, Santa Barbara, California 93106; 805-893-4486.

Eighth IEEE Pulsed Power Conference (ED); June 17-19; Sheraton Island Harbor Hotel, San Diego, Calif.; Roger White, 619-576-7884.

University/Government/Industry Conference (ED); June 18-20; Melbourne Holiday Inn, Oceanside, Fla.; Thomas Sanders, Florida Institute of Technology, 150 W. University Blvd., Melbourne, Fla. 32901; 407-768-8000, ext. 8769/8763.

Joint Magnetism and Magnetic Materials-Intermag Conference (AIP & MAG); June 18-21; Pittsburgh Hilton, Pittsburgh; Diane Suiters, 5M³I Conference Coordinator, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-5088; fax, 202-347-6109.

International Conference on Communications (COMP); June 23-26; Denver Technical Center, Hyatt and Sheraton, Denver, Colo.; Russell Johnson, Western-Telecommunications Inc., 4643 S. Ulster St., Suite 400, Denver, Colo. 80237; 303-721-5650.

Antennas and Propagation Society International Symposium and URSI National Radio Science Meeting (AP); June 23-27; University of Western Ontario, London, Ont., Canada; A. R. Webster, Faculty of Engineering Science, University of Western Ontario, London, Ont. N6A 5B9, Canada; 519-679-6294.

International Symposium on Information Theory (IT); June 23-28; Budapest, Hungary; Anthony Ephremides, Department of Electrical Engineering, University of Maryland, College Park, Md. 20742; 301-405-3641.

Power Electronics Specialist Conference- PESC '91 (PEL); June 24-28; Massachusetts Institute of Technology (MIT), Cambridge; Martin Schlecht, MIT, Room 39-553, Cambridge, Mass. 02139; 617-253-3407.

Transducers '91: International Solid-State Sensors and Actuators Conference (ED); June 24-28; Hyatt Regency Hotel, San Francisco; Richard S. Muller, 497 Cory Hall, Berkeley Sensor & Actuators Center, Department of Electrical Engineering and Computer Science, Electronics Research Laboratory, University of California at Berkeley, Berkeley, Calif. 94720; 415-642-0614.

American Control Conference-ACC '91 (CS); June 26-28; Boston; Timothy Johnson, General Electric Co., Research and Development,

(Continued on p. 80B)

One Company's Vision Can Give Your Career A New View

GE Aerospace Military & Data Systems Operations states its mission simply. Be the premier contractor for sophisticated command, control and information systems. We're making our vision a reality through results-proven professionals like you.

Combine your expertise with our resources and you'll discover how we reach solutions that no one else can — on time, on budget and right on target. At the same time, you'll enjoy a level of involvement in national programs that few companies can match. You'll work in an environment that's constantly re-tooling for the future. And you'll thrive with the opportunities for professional development and advancement that GE offers, including an in-house, accredited Master's degree program.

We continually seek experienced, degreed systems and software professionals for opportunities in Valley Forge, PA, a thriving suburb of Philadelphia, and metropolitan Washington, DC.

Systems Engineers & Analysts Command & Control
- C^2 operations conceptualization and development
- Top-level systems design and requirements definition
- Segment design

Systems Engineers & Analysts Resource Management
- Operations research
- Man-machine interfaces
- Software lifecycle

AI Information Systems Analysts
- Natural language processing
- Image understanding
- Tactical data fusion
- ART, CLIP, KEE, Lisp and C++ languages

Computer Security Engineers
- Orange and Red Book Standards
- Network security
- Accreditation of trusted systems
- DoD 50200.28 criteria

Software Engineers/Software Analysts
- Software development for vast information processing systems and applications
- Hands-on experience with SUN/UNIX, VAX/VMS, IBM MVS/XA, C, Ada, Fortran, Pascal

System Capacity Planners
- System configuration maintenance & installation
- Maintaining a tuned operating environment
- IBM 370/390; MVS/XA, MVS/ESA; LAN/WAN; SAS, MICs

Communications Systems Engineers
- Architecture design, development and analysis of advanced satellite and/or terrestrial communications systems

Wang VS Systems Analysts
- Applications and utilities support to Wang VS users
- Hands-on knowledge of Wang VS system utilities, VS procedure language, 20/20 spreadsheet design and development, PACE and COBOL
- 3+ years Wang analytical support experience

Wang VS Systems Administrators
- User support and overall resource management for information centers with multiple Wang VS systems
- LAN/WAN operations experience
- BSCS or 3 years experience in systems administration

Application Programmers
- Software development for strategic business systems
- 3+ years experience with IBM and Macintosh, DB2 and IDMS

Systems Programmers
- Applications development and maintenance, installation of systems products
- Hands-on experience with large mainframe and system internals plus MVS/XA, CICS, VTAM, VM, SMP/E, ACF2, TMS, JES2, ASM2, VMP/HPO

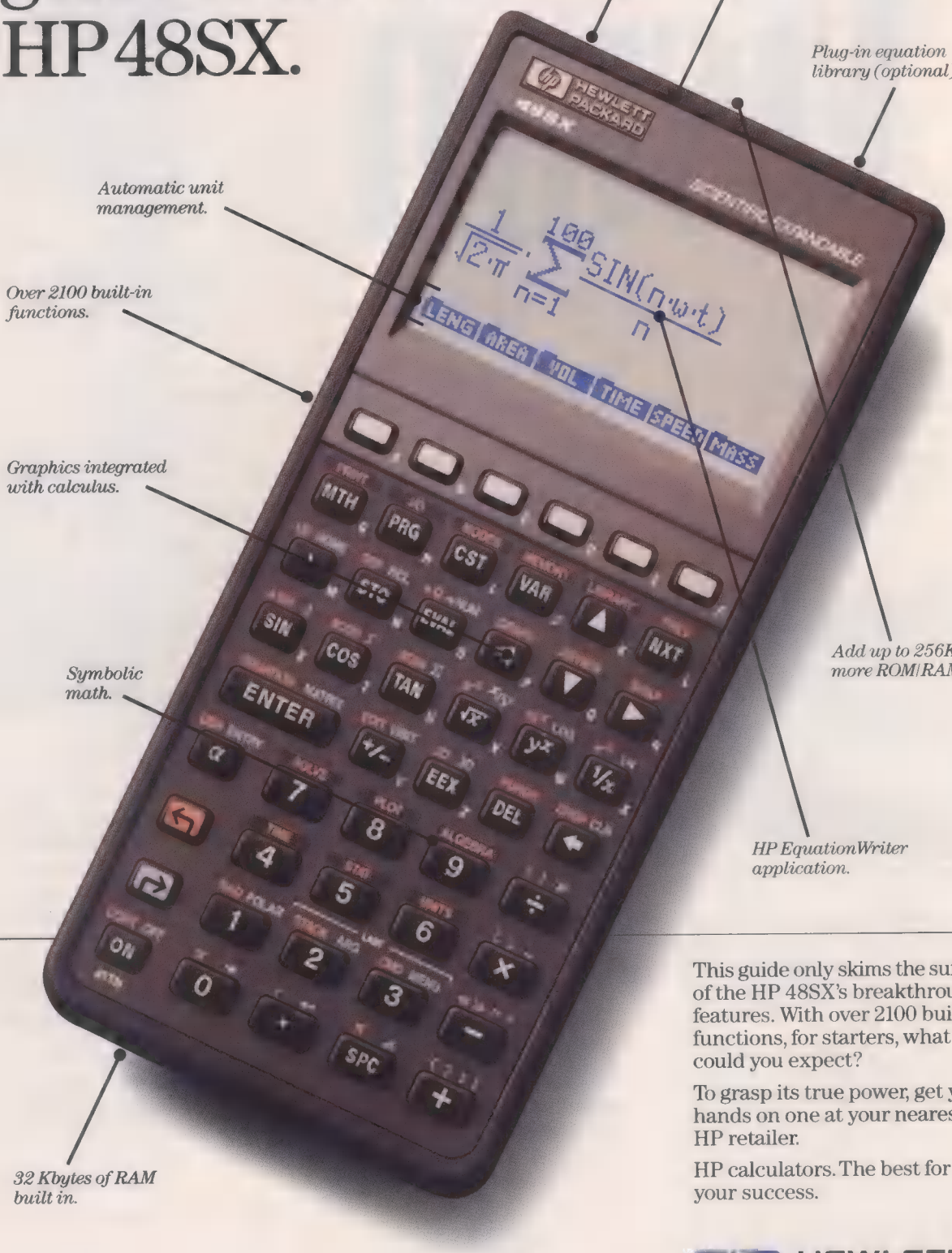
Relational Database Specialists
- Transform user requirements into relational models
- Hands-on experience with DB2, IDMS/ADSO, Adabas/Natural, M204, Oracle, Ingres, and Sybase.

U.S. citizenship and military or civilian experience in a sensitive classified environment are preferred for most positions.

The vision to make new ideas happen is a hallmark of M&DSO. Now make it the mark of your career. If you are interested in Valley Forge, please send your resume to: GE Aerospace Military & Data Systems Operations, Dept. BL01, P.O. Box 8048, Philadelphia, PA 19101. Washington candidates should send resumes to: Dept. BL01, 8080 Grainger Court, Springfield, VA 22153. An equal opportunity employer.

GE Aerospace
Military & Data Systems Operations

The power-user's guide to the new HP 48SX.



This guide only skims the surface of the HP 48SX's breakthrough features. With over 2100 built-in functions, for starters, what could you expect?

To grasp its true power, get your hands on one at your nearest HP retailer.

HP calculators. The best for your success.

HEWLETT PACKARD

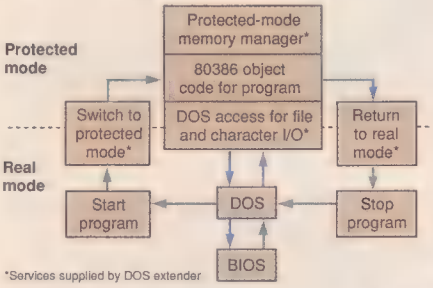
Simulated screen.

Large programs *can* run under MS DOS

For lack of enough linear memory, MS DOS computers cannot run engineering programs originally written for workstations or minicomputers with their megabytes of storage. The operating system, not the hardware, imposes this limitation. However, programmers who move software only to 80386- or 80486-based PCs can work around this by switching the program from real mode to 32-bit protected mode.

The problem is that all 80386 microprocessors using MS DOS must emulate the 8088, which can address only 1M byte of memory. Of this, 386K bytes are reserved for system hardware, 640K bytes for software. DOS, device drivers, and network software typically occupy 150K bytes, leaving less than 500K bytes for DOS application programs.

Consequently, to make ■ program written on a larger computer run in real mode in half a megabyte, scientific programmers must make major changes to the source code, inevitably introducing errors. In the 32-bit protected mode, in contrast, the 80386 or 80486 processor can address many megabytes of linear memory and has more (and faster) instructions.



Object code to switch programs from real to protected mode and back [see illustration] is supplied by the 386/DOS Extender Software Development Kit (SDK) by Phar Lap Inc. The kit also supplies protected-mode service routines in place of DOS' real-mode memory management routines, as well as additional protected-mode services not available from DOS. It does not supply character or file input/output services, though, since both can be accessed by switching the program temporarily back into real mode.

The SDK works with over 30 different 32-bit compilers for 15 languages ranging from Ada to Smalltalk. Most scientific software development using Phar Lap is being done with C or Fortran, but Phar Lap also supports APL, Basic, and Pascal.

Programs that use Phar Lap's extender can be run with most other protected-mode software. The 386/DOS Extender now supports both the VCPI (Virtual Control Program Interface) and DPMI (DOS Protected Mode Interface) protected-mode programming standards. The VCPI standard guarantees protected-mode programs can coexist with protected-mode memory managers like 386MAX that support VCPI. The DPMI standard guarantees that protected-mode programs can run under Windows 3.0, OS/2, DOS under SCO Xenix/386, and other multitasking operating environments that support DPMI.

A 386/DOS Extender Software Development Kit that includes the 32-bit extender, assembler, linker, object library manager, and assembly code debugger sells for US $495. Bindery utilities to produce *.EXE files and a license to distribute 1000 programs cost an additional US $1995. However, the ability to transport workstation and minicomputer engineering programs directly to DOS without significantly modifying the source code usually justifies the initial cost of the package. *Information on VCPI can be obtained from Phar Lap Software Inc., 60 Aberdeen Ave., Cambridge, Mass. 02138. For a copy of the DPMI specification, contact Intel Corp. at 1-800-548-4725 or write to the Intel Literature Department, JP26, 3065 Bowers Ave., Box 58065, Santa Clara, Calif. 95051-8065.*

Compilers affect portability

Software engineers who are moving programs from minicomputers or workstations should select ANSI or ISO standard compilers that are source-code–compatible with compilers on other platforms or come from vendors who supply compilers for other platforms. This will not guarantee portability, but fewer problems will arise when applications are moved from one platform to another.

Lahey Computer Systems Inc. supplies F77L-EM/32, an ANSI 77 standard Fortran 32-bit 80386 protected-mode compiler that is compatible with Lahey's FL77L DOS and OS/2 compiler. As it can also directly compile most IBM VS, Microsoft, and VAX Fortran source code, transporting Fortran-based number-crunching programs to a 386-based IBM-compatible computer becomes relatively simple.

The compiler comes with a complete set of development tools. It has an editor with on-line help for quick program creation, ■ MAKE utility to maintain programs with multiple source files, and ■ graphics library so that PC graphics may be added to the minicomputer source code. It is a turnkey package—unless the optional library of mathematical subroutines is purchased.

The Lahey compiler offers other features that are useful to scientific programmers. It supports the Intel, Cyrix, and Weitek math coprocessor chips, so programmers can write code that takes advantage of the improved performance of the Cyrix and Weitek chips. Subprograms can call themselves so that recursive algorithms may be used in Lahey Fortran. Also, function object code generated by the MetaWare High C 386 compiler can be called by the Lahey compiler, and subprogram object code created by the Lahey compiler can be used by the MetaWare compiler.

Lahey also sells a proprietary DOS extender based on Ergo's OS/386 DOS Extender for the compiler. Programs compiled with the Lahey compiler and extender can be sold without paying additional royalties to either Lahey or Ergo. Because the current version of the DOS extender supports VCPI but not DPMI, programs generated with this compiler cannot be run under ■ multitasking operating system. A DPMI-compliant extender should be available from Lahey early in 1991. *Contact: Lahey Computer Systems Inc., Box 6091, Incline Village, Nev. 89450; 702-831-2500.*

The soft sell

Many scientific software programmers who have developed applications for the Macintosh use a HyperCard stack instead of paper advertising to show customers what the program can do. A few minutes of text, graphics, screen captures, and sound on Macintoshes tells more about the program than hundreds of pages of hard copy.

Scientific programmers who have written applications on the PC can use KnowledgePro (Windows) by Knowledge Garden Inc., a graphical version of its KnowledgePro knowledge-base generator that runs under Windows 3.0. A compiler for creating Windows 2.x and 3.0 application programs accompanies KnowledgePro, allowing programmers to create and distribute royalty-free stand-alone demos, tutorials, and references that run under Windows. KnowledgePro (Windows) is ■ complete package for creating knowledge bases, which are programs that store and display text, graphics, and sound.

Knowledge bases are cost-effective tools. There is no overhead since they can be produced when needed, one at a time. They can be shipped by first-class mail on floppy disks instead of fourth-class book rate—or transmitted electronically when needed. And they can be upgraded instantly.

Most programmers will use KnowledgePro to create filmstrip-like demos, but they can also use it to make interactive tutorials. Engineers and technical writers can use KnowledgePro to create on-line manuals and references; a complete set of reference manuals is available with any PC and modem. Other engineers can use it to create expert systems, since an expert programmer is not required. Furthermore, KnowledgePro also touts it as a tool to create general Windows applications.

Simple 5-minute filmstrip-like demos with graphics and sound can be created with KnowledgePro (Windows) in just a couple of days. More powerful interactive demos take ■ week or two, while in-depth interactive tutorials and references need ■ month. The company lets the scientific programmer add value to his or her software by shipping CAI (computer-aided instruction) material with its software package. *Contact: Knowledge Garden Inc., 473A Malden Bridge Rd., Nassau, N.Y. 12123; 518-766-3000.*

Coordinator: Gadi Kaplan
Consultant: John Kellum, Intergraph Advanced Processor Division

It's not easy being top dog.

Sometimes it's harder to stay out front than it is to get there. That's why you need a CAE environment designed to keep the competition where it belongs. Behind you.

Presenting Ctrl-C and Model C. Ctrl-C is the interactive command-driven language for classical and modern control design and analysis, signal processing, system identification and optimization, and engineering graphics. Model-C is the block diagram modeling and simulation program for workstation environments. It simplifies all phases of systems engineering, on projects ranging from chemical process modeling to underwater propulsion. Features include hierarchical model construction for mixed continuous and discrete systems, linearization, and automatic code generation.

Ctrl-C and Model C from Systems Control Technology, Inc. When you want your project to fly, there's no better way to get it off the ground.

For more information contact the CAE Systems Sales Department at 800-227-1910, telex 176451 SYSTEC PLA, fax 415-496-6595, or write to 2300 Geng Road, Palo Alto, California 94303. CAE Systems is a division of SCT, Inc.

SCT

Ctrl-C available for 386 PCs, Sun, Apollo and DEC workstations, DEC mainframes and Convex. Mac versions available soon. Model-C available for VAX and Sun 3 workstations. SPARCstation, DECstation and Mac version coming soon. CtrlC® and Model-C™ are trademarks of Systems Control Technology.

DECEMBER 1990 • VOLUME 27 • NUMBER 12

College ($) woes

At many private U.S. colleges and universities, most students need help in paying for their education, whether in the form of loans, grants, or ■ waiver by the school of tuition or fees (another form of grant). Even at state colleges and universities, the annual cost per student can exceed US $7000. But that figure is in line with what many families can afford, whereas at private institutions, the sum can triple.

The annual cost per student at Worcester Polytechnic Institute (WPI) is $20 035, for instance. Fewer than 30 percent of WPI students can afford it—the rest require financial assistance.

At the Massachusetts Institute of Technology (MIT) the cost per year is $20 700, with 55 percent of the undergraduates requiring financial help; at Stanford University the figure is about the same, with 60 percent needing aid; and the California Institute of Technology charges $17 470, with 75 percent requiring aid. The picture is similar at Cornell University, Princeton University, and other Ivy League schools.

At WPI and Cornell University, as at many other colleges and universities, the admissions policy is "need blind," which means that students are admitted regardless of their ability to pay. For those schools and others like them, the percentage of students requiring financial help will continue to rise in the foreseeable future, until nearly all students will require aid. Consequently, the annual increases in tuition will be "paper" increases for many students; the net dollars accruing to the school will be significantly less, since loans and grants will not be sufficient to close the gap and the schools will "forgive" the difference.

At Cornell, for example, where the cost for an engineering undergraduate is $20 164, 72 percent of the 1990–91 freshmen received financial aid, and 45 percent got need-based aid directly from Cornell.

The amount of college/university operating funds allocated to student support is rising out of proportion to other costs. In 10 years, the figure at Cornell has nearly quadrupled, to more than $28 million.

Of no help is the Government's cutback on student aid programs.

One noticeable result of the financial pressures on the schools is their increasingly ambitious fundraising targets. Cornell has mounted a $1.25 billion campaign (thought to be the highest yet by ■ U.S. university) with ■ 1995 deadline. WPI has just concluded a $52.5 million campaign that was oversubscribed. Stanford is looking for $1.1 billion by 1992.

The dollar gap is under serious scrutiny at every U.S. college. Many are considering abandoning the need-blind admissions policy. Smith College has already done so. Others are considering how to become more attractive to "elite" students (elite in this context defined ■■ having less financial need, not as better qualified). One engineering school is looking at the possibility of creating special programs for non-U.S. undergraduate or graduate students, "ideally with endowment ■■ well as tuition income," as well as increasing the number of non-U.S. undergraduate students, who pay full tuition.

Others are looking to streamline their operations or to focus on excellence in fewer areas. Columbia and Northeastern are typical of those cutting programs. Still others are considering reducing operating expenses by increasing the student/faculty ratio or otherwise increasing the faculty workload.

Ideally, one would hope for an undergraduate education system that would not discriminate on the basis of financial need, but rather would screen the best of the talent pool for the most demanding professions. But present trends suggest this policy is putting U.S. colleges in an untenable financial bind.

Instant cachet

Traveling on ■ New York City bus the other day, I noticed a young man wearing ■ New York Mets baseball cap. Nothing unusual here. Half the youngsters in New York own a Mets cap; the other half, ■ Yankees cap—some both. Seated next to the Mets fan was a gentleman wearing a Boston Celtics warm-up jacket. Not for a moment did I believe he was associated with the Celtics—he was too short! Next to him was a young lady wearing a sweatshirt with the University of Hawaii logo, and across the aisle sat an older, bearded man sporting a Sorbonne T-shirt. Somehow I was skeptical about the relationships of all these people to the respective organizations advertised on their apparel.

Cathy Wassylenko

The youngster probably got his headgear at a Mets cap day. The young lady, or her boyfriend, may have been a member of a University of Hawaii team—but I doubted it. Most of this apparel is available through catalogs, or at airport gift shops. In the better department stores this fall, one can purchase battered sweatshirts with worn insignia of major universities that suggest the wearer is at least ■ senior, if not a post-grad.

There was ■ time when the accoutrements of sporting teams or scholastic organizations were closely guarded, to be worn only by the truly eligible. Coaches sometimes would even bar their squads from wearing warm-up jackets anywhere but on the playing field.

It's different today. Military personnel go on leave in mufti, seldom in uniform. Conversely, civilians treasure bomber jackets, peacoats, and various insignia and uniform parts as wearing apparel. Impersonating a member of the armed services was once illegal, wasn't it?

Now the ineligible and the nonqualified seem to be strongly attracted to the artificial cachet.

Can it be but ■ short step to the overt merchandising of faux certificates, diplomas, and the like to the general public? Perhaps such credentials will become elements of home decor, sought by interior designers to impart a prestigious touch to the living room or study. The genuine item may be prized even more highly. Decorators may roam flea markets and yard sales for rare or unusual diplomas discarded by undiscerning relatives.

A black market may develop. Discriminating burglars may pass up VCRs in favor of exotic certificates of high scholarship or professional accomplishment.

So be careful. Your marks of distinction may soon have more than psychic value. *—Donald Christiansen*

'90s employment: some bad news, but some good

The current job outlook differs radically with the country, with economic conditions, with national policy, and with engineering field

Over the past year in the United States, nearly a quarter of a million engineers and other employees in high-tech companies have lost their jobs. An undetermined number were electrical engineers.

Hardest hit have been big computer and aerospace companies. Widely publicized defense cutbacks are only part of the story. In the general civilian economy, layoffs have resulted from company mergers and decreases in the market demand for certain major electronic products (such as minicomputers)—not helped by increasing energy costs resulting from Iraq's invasion of Kuwait and the seizure of its oil fields. Moreover, by late this year, in many circles discussants were bringing up the dreaded R-word: recession. And since late 1989, based on leading economic indicators, the IEEE's Engineering Manpower Committee has been projecting that the employment outlook for EEs will grow worse before it gets better, hitting bottom early next year.

Canada also seems to be suffering the beginning of a recession—in part perhaps because its economy is strongly linked to that of the United States. In Ontario alone during the first nine months of this year, 132 companies have eliminated nearly 19 000 jobs, compared with 11 500 for all of last year.

Times are also somewhat tough even in the formidable newly industrialized country Taiwan. Its heavy reliance on imported crude oil from the Persian Gulf has hiked operating expenses, while economic difficulties in the United States have decreased demand for all electronic products.

Meanwhile, some engineers in such nations as Britain, France, Germany, and India seem never to have had it so good—although there are conflicting signals. With the high-tech plans for a unified European market after 1992, the unification of Germany requiring the reconstruction of the industrial infrastructure of the former East Germany, and the Indian Government's encouragement of computer and software industries in an effort to ready its economy for the 21st century, many company leaders feel new engineers are not being trained fast enough. For the short term, these countries are even considering the importation of non-national engineers to fill the demand. But over the long term, some analysts predict that even France and Germany may face a slight rise in unemployment. As yet unclear are the effects and ultimate significance of the recently announced layoffs of 7000 employees from the Italian computer and office equipment giant Ing. C. Olivetti & Co. S.p.A., 7500 workers from the French computer manufacturer Groupe Bull, and up to 55 000 people by Philips NV of the Netherlands.

Japan's economy is hovering between boom and bust. Although some slowing of demand there for high-tech products is pinching the revenues of major companies, company managers so value the experience that comes only with lifelong employment that they are taking every measure possible to avoid laying off engineers and other employees, even if in the short run cutbacks might improve the ubiquitous bottom line.

Despite the overall grim picture with large companies in the United States—particularly those dealing with hardware and those in the Northeast—high-tech companies with fewer than 1000 employees are still growing, some very rapidly. Indeed, so many of them are still creating jobs that, at least for now, they seem to be somewhat mitigating the effects of the massive cuts at their big-corporation counterparts.

Obviously, the global picture of trends in engineering employment is complex. To the best of anyone's knowledge, what is the current outlook for engineers and their jobs—both over the next year and through the decade to 2000? What engineering industries are harder hit than others—and which are more robust? How can engineers prepare career and job strategies for survival—for both their companies and themselves?

This special report, the product of an *IEEE Spectrum* editor and seven international correspondents, draws on both statistics and individual case studies to ascertain the level and implications of worldwide disruptions and opportunities.

Trudy E. Bell Senior Editor

1. Job security, soft in North America, has strong spots in Europe and Asia

How safe is your job? The answer seems to depend on where you are. Some countries view employees as expendable resources to be cast aside when times are tough and acquired when economies improve; others see them as a long-term capital investment to be protected during the bad times in order to be ready with depth and expertise for the good times.

0018-9235/90/1200-0032$1.00©1990 IEEE

According to some analysts, job security is an anomaly. In those places where it still exists, sometimes it is a matter of custom—and sometimes a matter of law. Where it becomes a matter of law, a good thing for employees can pose certain challenges to employers.

A tale of two countries

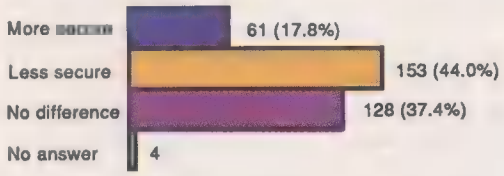
In the United States, employees are often viewed as "expendable commodities," with engineers being no exception, said Robert A. Rivers, president of Aircom, Union, N.H., and the member of the IEEE Manpower Committee who is in charge of employment forecasting. "When push comes to shove, you've got two weeks' tenure, assuming the average paycheck comes every two weeks," he said. "If you think you've got more, you're kidding yourself."

Even companies such as Digital Equipment Corp., headquartered near Boston in Maynard, Mass., which have long maintained a policy of no mass dismissals during economic downturns or corporate reshufflings, are now "emphasizing getting people to leave," said one of the many hardware engineers in Digital's Marlboro, Mass., plant who were notified in early October that they were "at high risk of being put on transition." "On transition" is Digital's code phrase meaning that a job's existence is no longer guaranteed.

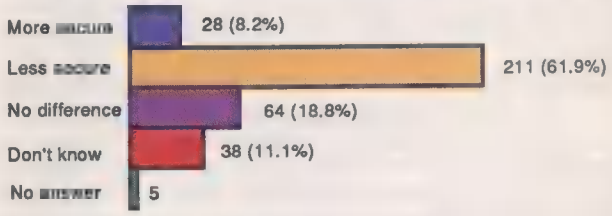
Across the United States, the layoffs, early retirement packages, settlements, and plant closings have assailed employees on

Some results from an *IEEE Spectrum* survey:

Do you feel your job is more or less secure than it was two years ago?

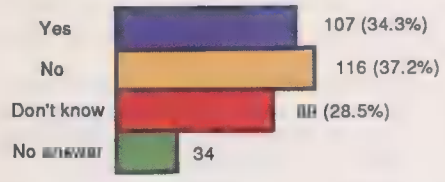


Do you think your colleagues feel their jobs are more or less secure than they were two years ago?

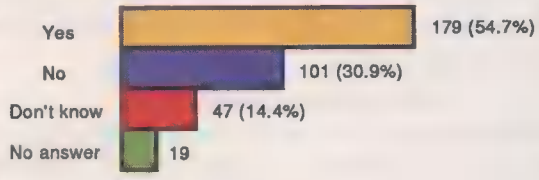


Do you see any opportunity with your organization to move to a more interesting or rewarding job?

Is this likely to occur?

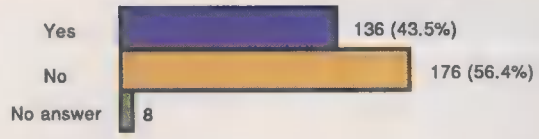


Is your company increasing its sales volume?

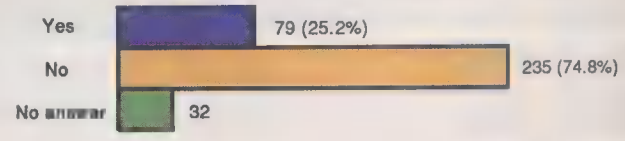


Is your company involved with military work?

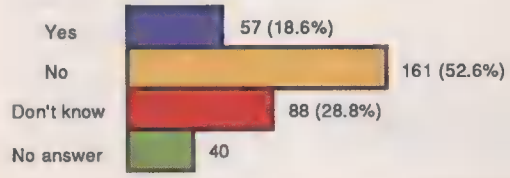
Are military cutbacks hurting your company?



Are military cutbacks hurting your job?



Does your company have any plans to convert military work to non-military work?



[1] A majority of electrical engineers feel that their jobs are somewhat less secure than they were two years ago, but do not necessarily ascribe this insecurity to cutbacks in military spending. Those are two conclusions drawn from a survey of 1500 IEEE members conducted by IEEE Spectrum *in May, of whom 346 responded.*

a scale not seen since the recessions of 1982 and 1974. In the third quarter of this year, 49 companies announced 49 104 permanent cuts, compared with 11 companies cutting 24 085 workers in the third quarter of 1989 [Table 1]. Furthermore, that was the sixth quarter out of the past seven in which the computer, aerospace, or telecommunications industry has led the pack, according to human resources specialist Dan Lacey, editor of the semimonthly newsletter *Workplace Trends*. Moreover, the numbers regularly represent 5–20 percent of the companies' payrolls [Table 4].

Working engineers in the United States are feeling increasingly apprehensive about their job security, according to a survey of 1500 U.S. IEEE members conducted last May by *IEEE Spectrum*. Some 44 percent of 346 respondents—59 percent of them nonmanagerial technical personnel—said their job seemed less secure than it did two years ago, and nearly 62 percent felt their colleagues were less secure [Fig. 1]. A full 45 percent felt there was no opportunity within their organizations to move to a more interesting or rewarding job.

Fear about job security was ranked as the No. 1 career issue for the second year in a row, according to the 1990 annual salary and opinion survey conducted in July by *Electronic Engineering Times* of 2500 subscribers, corroborating the *Spectrum* survey's results.

Attitudes in Japan differ markedly, even in hard times. The *EE Times* survey, which also polled 1000 readers of *Nikkei Electronics* magazine, reported that Japanese EEs rank job security only eighth in their list of concerns, after technological obsolescence, salaries, engineers' image, patent rights, and others.

The difference between the United States and Japan reflects the engineering management of large companies. "We will avoid layoffs at all costs," declared Makoto Maruyama, general manager of the personnel relations division of NEC Corp., Tokyo. "We will not duplicate America's management system. NEC believes it has better engineers than other [Japanese] corporations, and wants to keep them."

Maruyama feels that the Japanese custom of lifetime employment "has strong merits" for both sides. "The employee gets a feeling of stability and security," he said, while the company "gets a return on its large investment of time and money in education and training," amounting each year to about three-quarters of the total salaries paid. Maruyama said NEC will keep lifetime employment "because it makes the best use of the depth of knowledge accumulated by our engineers, which results in high product quality. Job hopping leads to broad knowledge, but not depth."

Similarly, "Toshiba doesn't 'unemploy': our people have a stable employment position," said Akio Kameoka, senior manager of the technical planning and coordination division of Toshiba Corp., Tokyo. "Major companies in Japan secure their engineers' positions by allocating them in an optimum way." If they need to be reassigned from slower divisions to more promising lines of business, he noted that Toshiba has "an internal education and training system to accommodate these redeployed engineers, and in fact, some plants have their own technical school." About the most radical move Toshiba might make in really tough times is a reduction in managers' salaries, or a transfer of work previously assigned to a subsidiary back to a company's corporate staff, he said.

1. Synopsis of permanent staff cuts announced by U.S. corporations in 1989 and 1990

	Quarter	How many positions cut	...by how many companies	Dominant industry(ies)
1989	1st	9 850	6	Computers
	2nd	10 100	3	Aerospace
	3rd	24 085	11	Automotive
	4th	67 250	35	Computers, telecommunications
	Total	**111 285**	**55**	—
1990	1st	110 152	46	Automotive, telecommunications
	2nd	87 686	44	Aerospace, retailing
	3rd	49 104	49	Computers, aerospace
	Total to date	**246 942**	**139**	—

Source: Workplace Trends

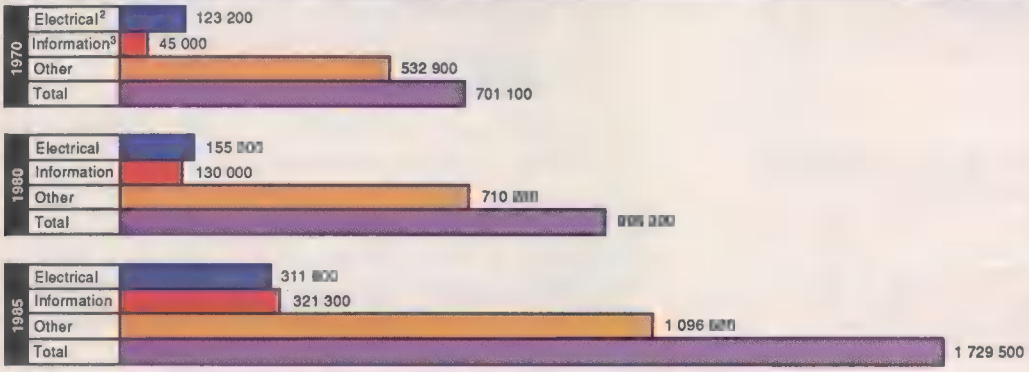
European companies also seem to have a long-range view, keeping their employees even in difficult times. According to Thomas Utrecht of the German Government's Federal employment agency ZAV (Zentralstelle für Arbeitsvermittlung), company loyalty is widespread in Germany. "Almost half of all German engineers never change their company," he said.

The French hold a similar view. "We won't let our hard-earned, highly trained engineers go just when the battle for survival in the 21st century is being prepared!" said Jacques Benayoun, head of human resources at Thomson SA in Paris. "The American problem [of unemployed engineers], doesn't it come from a certain short-sightedness?" he asked. "As soon as a business starts losing money, it lets them go. And then what? The crisis is larger than a mere employment crisis, in my opinion," he added. "It's a crisis of human values, of priorities."

Europe: lands of opportunity

"In France, we have an employment problem for engineers: there aren't enough of them," declared Bernard Faure, director of personnel and social affairs at Philips Components in Paris. He maintained this outlook even though by late October, Philips'

Engineering employment in Japan, 1970–85[1]



Source: Management and Coordination Agency
1 Data extrapolation based on 20 percent sample tabulation; 2 Includes electronics; 3 Includes hardware and software

[2] Japanese employment of all engineers has increased 2.5 times between 1970 and 1985, with employment of electrical and information engineers growing by 3.8 times. The greatest demand for them has been in services, manufacturing, and construction, with strong growth also in utilities as well as in wholesale and retail operations.

corporate headquarters in the Netherlands had announced two worldwide staff cuts at all levels of the company totaling 45 000 to 55 000 people by the end of 1991. The reason for the cuts given in an official press release is that the company has "embarked upon a major efficiency drive. . .with the aim of restoring the company's profitability," particularly in the fields of integrated circuits and computers. Company spokesmen responded "No comment" to further questions. As of Sept. 30, 1990, the company employed 285 700 people worldwide.

France's educational system is currently graduating about 15 000 engineers per year—roughly the same number per capita as the United States. The French Federation of Electrical and Electronic Industries, however, estimates that the country needs some 24 000 or 25 000 per year to fulfill the current and anticipated demand.

The demand for engineers in France—arising in part from the aggressive high-tech programs in anticipation of the unification of the European markets in 1992 [see "Europower," June 1990]—is so strong that Philips' Faure believes it will even resist cutbacks in military spending as a result of improved international relations between North Atlantic Treaty Organization (NATO) and Warsaw Pact nations. Reduction of military projects "will be more than compensated by growth opportunities in space electronics, telecommunication, airborne electronics, computers, and consumer electronics."

"German electrical and electronic engineers have good reason to be happy," said Karl-Heinz Grasselt, responsible for issues dealing with education and training at Verband Deutscher Elektrotechniker (VDE), or Association of German Electrical Engineers, headquartered in Frankfurt am Main. Over the past 25 years, the former West Germany's electrical and electronic product sales have increased sevenfold. This has created a strong demand for EE engineers and technicians, who together account for some 15 percent, or 1.1 million, German jobs. (These figures refer mostly to the former West Germany. At the moment, little is known about East German engineers—even their sheer number—and it is still too early to speak of a united German market. VDE has begun studying these basic facts.)

Last year, the German Federal employment agency ZAV reported that there were only 1.3 applicants for every engineering position open, compared with 143 applicants for every position open in sociology. The Deutsches Bundespost—Germany's public service mail and telecommunications carrier and the country's largest employer—was unable to fill some 2700 engineering positions.

Projections this year call for production of EE goods to have grown between 4 and 5 percent, according to VDE. Among the industrial sectors expanding above average are telecommunications, measurement systems, computers, and medical equipment. In addition, in 1987 almost 17 percent of Germany's 180 000 EEs were 50 years of age or older. Assuming these engineers retire over the next 10 years, VDE estimates that 4–6 percent per year more engineers will be needed to meet the demand.

In Britain, the employment outlook for engineers is complex, but various analysts agree that overall the country will need more. The University of Warwick's Institute for Employment Research is predicting that by the year 2000, about 10 percent of the 2 000 000 jobs in various engineering industries will be lost, mainly by unskilled labor. The industries declining most precipitously are shipbuilding, metal goods, aerospace equipment, and instrument and mechanical engineering [Fig. 3].

Offsetting these losses, however, are gains for engineers in office machinery, data processing equipment, and electrical engineering. Over the next five years, the number of engineering graduates is expected to fall by 500 000, while the demand for scientists and professional engineers is expected to rise by more than 25 percent by 2000, said Richard Pearson, deputy director of the British Government's Institute for Manpower studies.

The Engineering Council, a seven-year-old trade organization supported by 300 British engineering employers, said that the unemployment rate for engineers has been about 1 percent. According to the council's spokesman, Ron Kirby, "There is a great shortage of engineers in this country. Anyone who is qualified has a job." He added: "The greatest demand is for electrical engineers and technicians."

India: driving toward the 21st century

Perhaps somewhat unexpectedly, India is also a country that apparently has a voracious demand for engineers. Until the 1980s, the Indian Government had not given a high priority to high-tech products as the populace required more basic necessities first. In 1982, Prime Minister Indira Gandhi introduced color television, and by the time of her assassination in 1984, the Government was opening one TV station per day.

The real turnabout, however, came when her son Rajiv Gandhi took over as prime minister. He removed many import restrictions, reduced customs duties, and beefed up the telecommunications and electronics infrastructure. He also established a new Department of Telecommunications, and in 1985 announced a Telecom Policy that for the first time permitted non-Indian collaborative endeavors in the private sector to manufacture telecommunication equipment.

Today anyone in India can import components and assemble computers and other electronic goods. Telephone exchanges are moving to digital; although there are only 4 million telephones now, the Indian Government aims to quadruple that number by 2000. New computer firms are springing up and large computer networks are being installed. In 1989, 5 million TV sets were produced, as well as 4 million tape recorders of all kinds and 3.5 million electronic watches. This year India also started manufacturing stereos and microwave ovens. Overall the electronics industry is growing at an annual rate of 35 percent.

The result is anomalous: a growing demand for EEs in a nation with 33 million registered unemployed persons. The Government's Department of Electronics estimates that by 1995, India will require at least 225 000 computer professionals with advanced training. Today only about 60 000 are available.

Job insecurity?

There is just beginning to be some question about how long the philosophy of lifetime employment—which, in any event, is not universally practiced except in large corporations for fulltime employees—will last in Japan. "The security system has been rigid for the past two

2. West German EE job market for professionals and executives, 1981–89[1]

Year ending Dec. 31	Available jobs		Applicants		Jobs assigned through ZAV[1]	
	Total	Change over previous year, percent	Total	Change over previous year, percent	Total	Change over previous year, percent
1981	3116	−18.8	2615	+ 58.2	1636	+ 34.1
1982	1264	−59.4	4201	+ 60.7	1416	−13.4
1983	1814	+ 43.5	4627	+ 10.1	1252	−11.6
1984	3342	+ 84.2	3543	−23.4	1983	+ 58.4
1985	4778	+ 43.0	2448	−30.9	1704	−14.1
1986	6618	+ 16.6	2148	−12.3	1662	−2.5
1987	3888	−29.5	3007	+ 40.0	1629	−2.0
1988	2981	−23.3	3948	+ 31.3	1806	+ 10.9
1989	3315	+ 11.2	4768	+ 20.8	1777	−1.6

Source: ZAV

1 Made through the German Government employment agency, Zentralstelle für Arbeitsvermittlung (ZAV).

or three decades, but nowadays is gradually fading away" as an engineer's talent and capability play a larger role, said NEC's Maruyama. "After all, lifetime security is just a custom, not a law."

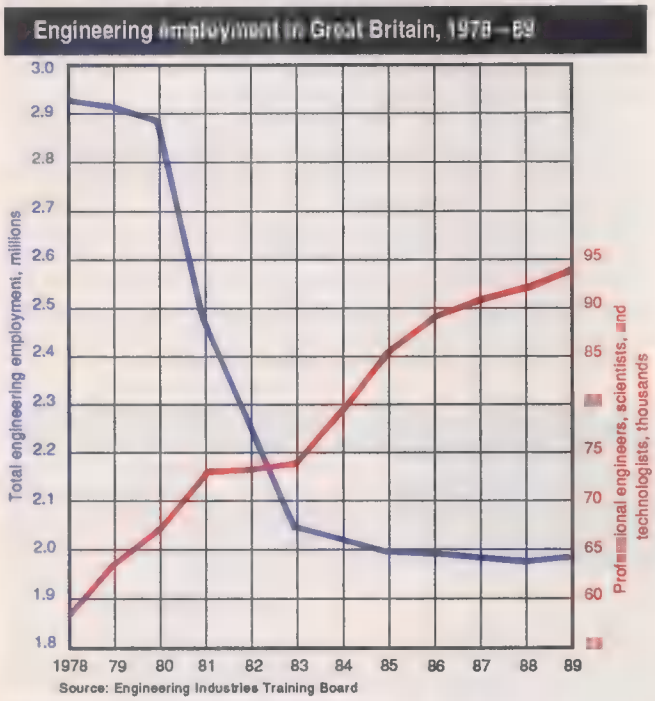
Over time "the management system in Japan will change a little, as the younger work force—more exposed to Western culture, and with different ways of thinking—moves into managerial positions," said Akiria Haruta, deputy director of the information services industry division of the Japanese Government's Ministry of International Trade and Industry (MITI). He acknowledged that while layoffs could eventually result from such management changes, compounded by severe economic conditions or natural disaster, "this is extremely hypothetical and very unlikely."

In addition, there is less commonality than appears between the Japanese and European in their approach toward long-term employment. "Europe has a stakeholder concept, where employees can be represented on the board of directors like coowners," explained *Workplace Trends*' Lacey. "Various statutes give people legal rights to their jobs." He pointed to the Vredling Directive, a proposal that has been under debate in the European Community for about a decade, which would require that companies give employees at least a two-year notice of plant closings.

In contrast, U.S. and Japanese employees have no statutory right to their jobs. "In fact, in the United States, where the overriding concept is 'at-will employment,' the law is to the contrary: workers serve at the will of the employer, minute by minute," Lacey said. In the recent mass of layoffs at high-tech companies, however, the great efforts to make the staff cuts voluntary is at the advice of company lawyers. "If a company gets rid of people, and doesn't force them to say it was voluntary, it could get sued for breach of implied contract or fair dealing," Lacey said. And since historically, the average cost of defending discrimination and wrongful discharge lawsuits has been about US $200 000, a layoff of 2500 people represents a potential US $500 million legal liability.

There are some movements afoot in the United States to give workers a stronger legal claim to their jobs, influenced in part by events in other countries. "The U.S. 60-day plant-closing law, which went into effect in 1989, is a derivative of the Vredling Directive," Lacey said. But the Vredling Directive, or any other such law, "has American-based multinationals worrying, because it means they have to tell competitors two years in advance what they plan to do," and also poses the problem of whether their European-based employees are given rights and benefits different from those of their U.S.-based employees.

Historically, "lifetime job security is an anomaly," Lacey said, citing the work of Yale University labor historian David Montgomery, who demonstrated that job security in the United States is a post–World War II phenomenon possible only because its economy was so strongly expanding. "The Japanese, which have a booming economy, are making the same false promise to their employees as the Americans did," he said. "The real test comes in the bust years," a conclusion also reached by S. Prakash Sethi, Nobuaki Namiki, and Carl L. Swanson in their 1984 book *The False Promise of the Japanese Miracle*.



[3] The employment of professional engineers, scientists, and technologists in Great Britain has continued to rise over the last decade even in hard times, although the total number of engineering jobs has declined. The growth in engineering jobs is particularly noteworthy since British unemployment during 1983–86 topped 10 percent.

2. Military, aerospace, communications, and hardware EEs are vulnerable

Not all the employees laid off are engineers, of course. Because many companies will not release breakdowns of the discontinued jobs, determining how many are technically trained personnel, let alone the number of EEs, is largely a matter of conjecture and anecdotal evidence.

Regardless of philosophy, though, software engineers today are in demand all over the world—even in countries where unemployment is rising.

United States: hardware companies hard hit

The largest—and virtually unheralded—long-term reduction in employees arguably has been the steady layoffs and early-retirement inducements in the telecommunications industry since the breakup of the AT&T Co. in 1984. In the past seven years, at least 150 000 jobs have been discontinued—amounting to nearly 25 000 jobs per year [Table 3]. An undetermined number have been engineers and other technical professionals, many offered very attractive early retirement packages.

More than 95 percent of the jobs lost have been from AT&T and the regional holding companies, many as part of an avowed, concerted effort to reduce central staff. Although the 1300 or so independent telephone companies have altogether shrunk by 10 000 jobs over the same period, it is likely that most of that shrinkage has been a natural by-product of the installation of more automated equipment. Overall, this attrition is particularly significant because traditionally the telephone companies have been the largest employers in telecommunications.

More recently, the U.S. aerospace industry has also been feeling the squeeze—due largely to pinched defense procurements and budgets. According to a report in the Sept. 10 issue of *Aviation Week & Space Technology*, since January alone "more than 45 000 defense-related jobs at major manufacturers have been earmarked for elimination in the next 18 months, and an additional 90 000–135 000 positions in the aerospace vendor base could be lost as a consequence of cutbacks at the prime contractors."

To put that into perspective, aerospace employment peaked at 1.3 million in 1987 and has been contracting since at the rate of about 1–2 percent per year. But by mid-1990, that slow pace "turned into an unexpected avalanche. . .catching many analysts off guard," the report continued. Still, the reductions so far announced do not approach the work force shrinkage of the early 1970s, "when U.S. aerospace employment plummeted from about 1 502 000 in 1969 to 820 000 in 1977," the report noted.

The majority of the 45 000 defense-related positions planned for elimination are in manufacturing. But most people in these

3. Decreasing employment in U.S. telecommunications industry, 1983–90

Date	AT&T Co.	Bellcore	Pacific Telesis	Southwestern Bell	Ameritech	U S West	Nynex	Bell Atlantic	BellSouth	[illegible]	TOTAL
12/31/83	983 000	—	—	—	—	—	—	—	—	186 800	1 169 800
1/1/84	373 000	7327	97 647	90 784	77 800	73 096	99 046	81 100	98 064	186 800	1 184 664
12/31/84	366 000	7414	76 881	68 133	77 500	70 765	94 918	79 500	95 704	179 944	1 116 759
12/31/85	338 000	7094	71 488	65 836	74 883	70 202	89 722	79 285	92 402	169 980	1 058 892
12/31/86	317 000	7345	74 937	61 774	77 538	69 375	90 489	80 185	96 886	165 357	1 040 886
12/31/87	308 000	7606	71 877	59 620	78 510	68 523	95 200	80 950	98 664	163 045	1 031 995
12/31/88	308 000	8182	69 696	57 970	77 334	69 765	97 583	81 000	100 280	169 767	1 030 763
12/31/89	286 000	8081	68 452	58 362	77 326	70 587	95 631	79 100	101 230	N.A.	—
9/30/90	279 000	8494	66 700	58 453+	76 000	66 000	93 917	81 000	102 558	N.A.	—

+As of Aug. 3, 1990. N.A. = Not available.
Source: United States Telephone Association and individual companies

jobs, unlike aerospace workers who have left jobs in the past, are expected to have trouble finding work within commercial sectors of the industry. In spite of record-sized commercial aircraft contracts let to McDonnell Douglas Corp. and Boeing Co., those companies are now expecting to lay off more workers, and hiring elsewhere in the commercial aircraft portion of the industry has stopped.

This has surprised analysts, since commercial products account for a much larger portion of the U.S. aerospace business today than they did in the 1960s and 1970s. According to the Aerospace Industries Association, a trade organization based in Washington, D.C., Government spending in the 1960s accounted for about 80 percent of U.S. aerospace sales—and thus Government cutbacks had tremendous influence—while today that spending accounts for only 55 percent of sales.

United States: small is beautiful

On the other hand, small to medium-sized companies in the United States "are growing and doing well in this economy," said Steven Parker, vice president of editorial operations at Corporate Technology Information Services Inc. (CorpTech). The Woburn, Mass., firm annually profiles some 35 000 high-tech companies in a four-volume directory. "Everyone knows that the larger technology companies are shedding people," Parker said, "but not all of technology is in the tank. That is news to most people."

In October 1990, CorpTech's ongoing survey of technology manufacturers showed that in the preceding 12 months, some 22 000 high-tech companies with fewer than 1000 employees reported that their employment had expanded by 5.3 percent, with one in six growing at more than 25 percent. During the same time, durable goods manufacturers as a whole reduced their staffs by 2.7 percent, according to the U.S. Department of Labor [Fig. 4]. Thus, smaller technology firms—which together employ more than 1.4 million U.S. workers—seem to be outperforming the rest of the manufacturing sector by a wide margin, Parker noted, perhaps because "smaller firms seem better able to react" to changing markets.

That trend has continued through this year, said Parker, although CorpTech's monthly surveys to update segments of 2000–4000 companies reveal some significant geographical and temporal trends. While in May the survey revealed that aggregate employment grew 5.9 percent over the previous 12 months, by October it had fallen to 3.3 percent, steadily decreasing over the intervening months. Thus, although employment at small and mid-sized companies has continued to grow, the rate of growth has been declining over the past half year, Parker said.

The technologies consistently at the top, with higher-than-average employee growth, are those dealing in pharmaceuticals, biotechnology, medical equipment, and computer software. Their growth is also related to the general health of the geographical region where the companies are located, with northern California leading the pack, followed by the south central and the southeastern regions of the country, in that order. In October, for example, 456 companies in the northwest grew by an aggregate of 8.3 percent, while 525 in New England grew by 1.5 percent.

The relative health of smaller companies can also be inferred from data collected by *Workplace Trends*' Lacey. Lacey, who has been monitoring staff cuts at U.S. corporations since late 1988, pointed out that overall last year 55 companies cut some 111 000 positions—but in just the first nine months of 1990, 139 companies did away with nearly 247 000 jobs.

Although fewer jobs disappeared later this year than earlier, Lacey pointed out that the number of companies that are cutting them has continued to grow, and "is higher this year's third quarter than in any quarter since the staff-cutting spree gained momentum in the fall of 1989." To him this means that the staff-cutting trend appears to be "moving down into the second-tier companies after getting its start with mega-corporations."

Lacey also warned against interpreting the peak figure in the first quarter of 1990 and the lesser figures since as meaning that engineers have already felt the worst. "Our numbers are somewhat prospective because we count them as companies announce them. Many haven't happened yet," he said, because some companies anticipate letting people go gradually over the next 12 months. "It's going to get worse," he predicted.

Software engineering is hot worldwide

Even in the countries where the electronics industry seems to be hitting the skids, software engineering is resisting the negative trend. And where engineers are in demand, software engineers are the most prized of all. In general, software is profitable because once it is developed, the costs of stamping out copies are a microscopic fraction of the costs of manufacturing hardware.

This year, while computer hardware companies were cutting staff, commercial software producer Microsoft Corp., Redmond, Wash., hired 1000 additional workers. Outside the United States, demand for software engineers is so great that various countries are looking beyond their borders to hire qualified personnel.

"We need engineers overseas, especially in software and semiconductors," said Seiji Igarashi, general manager of NEC's public relations. "Previously, most overseas subsidiaries of Japanese firms concentrated on manufacturing, but now we have to add the design and engineering functions."

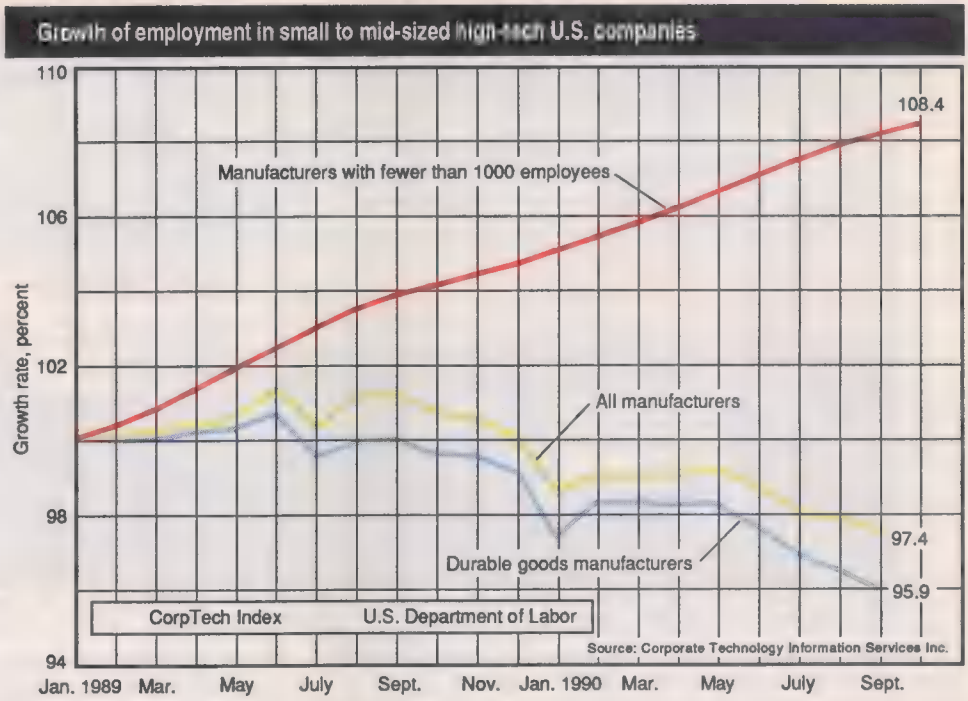
Looking toward filling the long-term demand for Japanese software engineers by efforts at home, MITI's Haruta said: "We're putting a great deal of emphasis on software engineering education in public and private schools." For example, Japan has asked Government agencies, such as the Central Agency of Information Technology, to devise the software engineering curriculum for colleges and technical institutes. "In addition, we'd like to develop software engineering capabilities in provincial cities, rather than having software engineers concentrated in Tokyo as they are now," Haruta said. Indeed, last year a law was passed to encourage local governments to cooperate with companies in es-

4. Some U.S. high-tech company cutbacks announced in 1990

When	Where	Work-force reductions		Total prior employment	How achieved	Reasons given	Main industry
		Total	Percent				
By end of 1990	AT&T Co.	13 000	5	283 000	Layoffs, 50%; attrition with incentives, 50%	Increase revenue while reducing costs; automation	Telecommunications
By May 1, 1991	BellSouth Corp. Atlanta, Ga.	3000	3[a]	101 000[b]	Early retirement options	Cut management staff	Telecommunications
By end of 1990	Boeing Co. Seattle, Wash.[c]	5600[d]	5	106 700[e]	Attrition, layoffs	Cuts in defense spending	Computers, defense
July 31, 1990	Contel Corp. Atlanta, Ga.	900	6	14 000	Early retirement	Restructuring to increase efficiency	Telecommunications
By end of 1990	Data General Corp. Westborough, Mass.	2000	17	11 700[f]	Layoffs	Reduce costs, improve efficiency	Computers
By end of July 1991	Digital Equipment Corp. Maynard, Mass.	5000–6000	4–5	123 500	Voluntary severance program, attrition	Run more efficiently; refocus for technology change	Computers
By end of 1990	Electric Boat Division General Dynamics Corp. Groton, Conn.	550	3	23 000[e]	Layoffs with 60 days notice	Cutbacks in military spending; cut support costs and managerial layers	Defense, submarines
By end of 1991	GE Aircraft Engines Cincinnati, Ohio	1500	4	37 500[e]	Attrition, layoffs	Cutbacks in military spending	Defense, aerospace
By end of 1990	General Dynamics Corp. St. Louis, Mo.	4000	4	102 200	Layoffs	Cutbacks in military spending	Defense, aerospace
By end of 1992	General Electric Aerospace Division King of Prussia, Pa.	4200	10	44 000[g]	Retirements, attrition, layoffs; in addition to 4000 in 1989	Cut costs; refocus on most profitable aspects of defense contracting	Aerospace
By end of 1990	Grumman Corp. Bethpage, N.Y.	750	8[h]	32 000[g]	Layoffs; in addition to 1900 in 1989	Cutbacks in military spending	Aerospace
By end of 1990	IBM Corp.	10 000[i]	5	216 000[e,j]	Voluntary incentive programs, limited hiring, attrition	Improve competitiveness, increase shareholder value	Computers
By June 1990	Lockheed Corp. Calabasas, Calif.	7200	9	82 500[e]	Cuts, layoffs, attrition, retirement, in addition to 9000 in last 2 years	Cutbacks in military spending	Defense, aerospace
By end of 1990	McDonnell Douglas Corp. St. Louis, Mo.	14 000–17 000[f]	10–13	135 000[f]	Layoffs, attrition, termination of contract positions	Reduce costs	Aerospace
1990	National Semiconductor Corp. Santa Clara, Calif.	2000	6	32 000[e]	Layoffs; laid off 2000 in January 1989	Become more profitable	Chip manufacturing
	Northrop Corp. Los Angeles	5500	13	41 000	-	Cutbacks in military spending	Aerospace
June 1990	Nynex Co. White Plains, N.Y.	4000	4	95 631[e]	Special retirement incentive program	Reduce costs, increase operating efficiencies	Telecommunications
By 1995	Pacific Telesis Group San Francisco	11 000	16	69 000	Retirement, attrition, resignation incentives	Cut costs, become efficient	Telecommunications
By end of 1990	Southwestern Bell Telephone St. Louis, Mo.	1600 (management)	3	58 362[e]	Voluntary cash incentives	Improve efficiency, reduce management	Telecommunications
By end of 1990	Tektronix Inc. Beaverton, Ore.	2700	18	15 136[e]	Layoffs, attrition	Reduce costs; sell or shut down unprofitable businesses	Test equipment
By June 1991	Texas Instruments Inc., Defense Systems & Electronics Division Dallas	1000	5	22 000	Eliminating jobs	Cutbacks in military spending	Defense, aerospace
By mid-1991	Unisys Corp. Blue Bell, Pa.	5000	6	78 000	Attrition, layoffs	Improve efficiency	Computers, defense
By mid-1993	United Technologies Corp.'s Pratt & Whitney[i] (Conn., Fla.)	4000	11	36 000[j]	Attrition, layoffs	Cutbacks in military spending; reduce costs for competitiveness	Defense, aerospace
End of 1990	US Sprint Corp. Kansas City, Mo.	1000[k]	5	20 000[e]	Layoffs, redeployment	Sales and marketing realignment	Telecommunications
By end of 1990	Varian Associates Inc. Palo Alto, Calif.	2200	18	12 100	Layoffs; sell several businesses	Improve earnings; focus on core businesses	Electronic components
Ongoing since 1988	Wang Laboratories Inc. Lowell, Mass.	9000[l]	31[l]	23 000[m]	Layoffs, attrition	Corporate restructuring	Computers

a 10 percent of management.
b 29 000 in management.
c Figures for Pacific Northwest Area only, not complete company.
d To date, reductions of 2350; expect to fall short of projection by 2700.
e Year-end 1989.
f Worldwide.
g Year-end 1988.
h Includes 1989 cuts.
i Stated objective.
j United States only.
k Does not include engineers.
l Since 1988.
m As of June 30, 1990; on June 30, 1988, employment was 29 300.
Source: the individual companies, except for Northrop Corp., where source is *The New York Times*

[4] High-tech companies with fewer than 1000 employees are showing faster growth and better economic health than large corporations, according to an ongoing survey of 35 000 U.S. technology manufacturers by Corporate Technology Information Services (CorpTech), Woburn, Mass.



tablishing institutions to educate company employees in software engineering and to bring programmers up to the level of systems engineers.

According to VDE, some 30 percent of all German EEs work in a software-related field. But unlike most other industrial powers, Germany has not concentrated on one specific area of EE production. Instead, it has sought to broaden its base to avoid major fluctuations in the market and in protectionist measures. Thus, according to a recent survey on opportunities for engineers in 1990 by Verein Deutscher Ingenieure (VDI), or Association of German Engineers, based in Düsseldorf, engineers in all major fields have excellent job prospects.

VDI's survey showed that the demand for engineers, as indicated by recruitment advertisements placed in the German media, grew by 13 percent in the first half of this year. That increase amounted to more than 5000 additional advertised positions. EEs were in the greatest demand, representing some 20 percent of the total. According to VDI's engineering personnel specialist Holger Hillmer, the demand for engineers has risen continuously since 1987. He expects EEs to remain in big demand throughout this decade as German industry continues to automate production and introduce microelectronics in manufacturing.

3. Technical, economic, and regional issues are employment driving forces

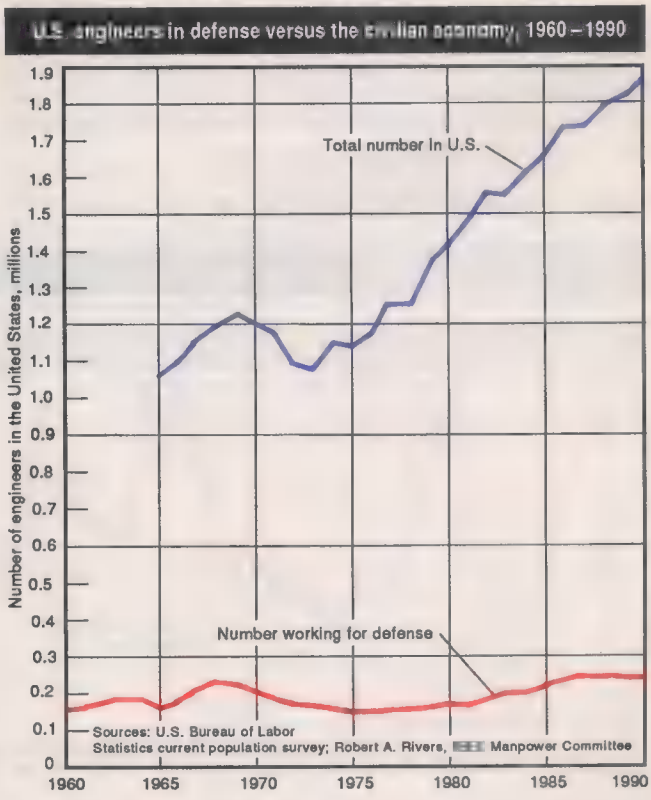
The widespread high-tech layoffs in some countries have some common causes, such as certain structural changes in the fundamental nature of engineering itself. Computer-aided design has eliminated ranks of draftsmen. Inspection, assembly, and testing are being done by robots, not technicians. Similarly, reasons for a high demand for engineers include overall ■ country's economic expansion, its having a favorable export balance, and a desire of its policymakers to be prepared for the 21st century. But to overlook the multilayered crazy quilt that characterizes the local conditions in each nation would be to pass over important lessons, global linkages, and future opportunities.

U.S. defense: secondary to general economic health

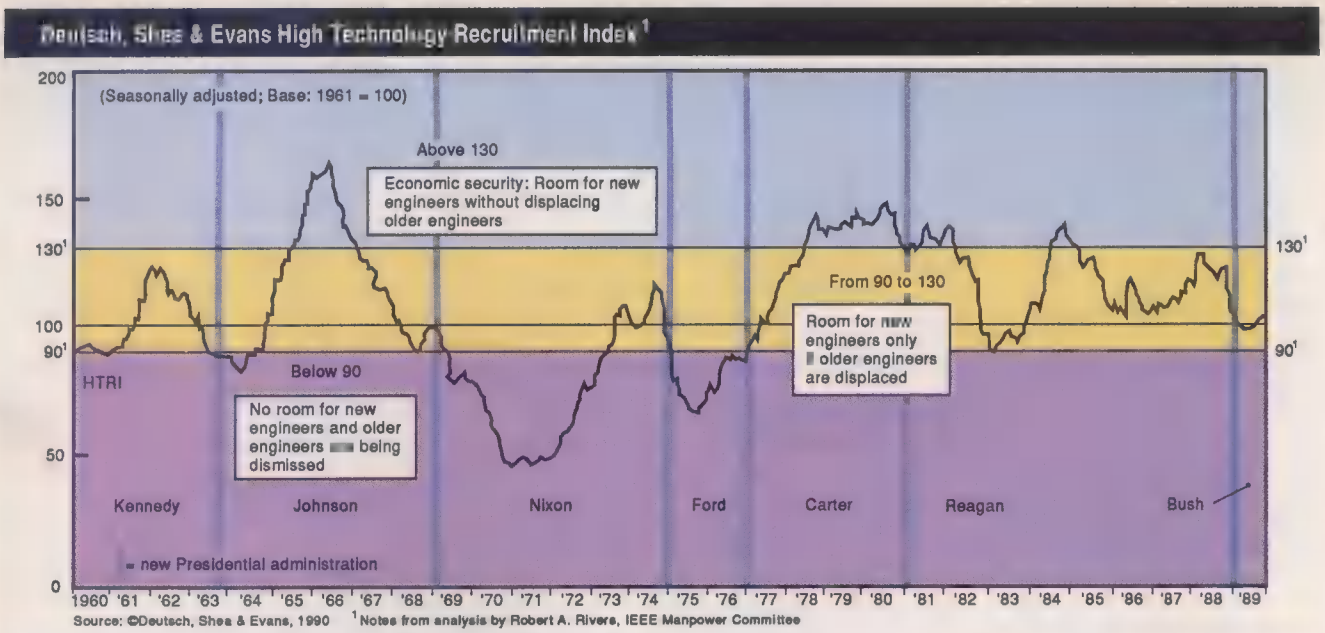
Contrary to widespread belief in the engineering community, cutbacks in the defense budget—although a very important factor—are by no means the principal factor driving the fortunes of high-tech engineering companies in the United States. The principal driver these days is the health of the general economy.

As figures from the Bureau of Labor Statistics and the Department of Defense demonstrate, "only one out of seven engineers—one out of six EEs—is supported by defense," declared the IEEE Manpower Committee's Rivers. In this context, the defense industry includes both engineers working for the Department of Defense itself and for prime contractors and subcontractors. [See "From swords to plowshares," *IEEE Spectrum*, November 1989, pp. 45–49.] This differs from the 1960s, before the burgeoning of the personal computer and consumer electronics industries, when defense supported ■ much higher proportion of engineers [Fig. 5].

"The Federal Reserve Board influences the economy through interest rates, and engineering employment is largely controlled



[5] The number of U.S. engineers working for the Department of Defense, prime contractors, and subcontractors in 1990 is only a few percent larger than it was in 1967, at the peak of the Vietnam buildup, whereas the number employed in the general economy is about 50 percent larger.



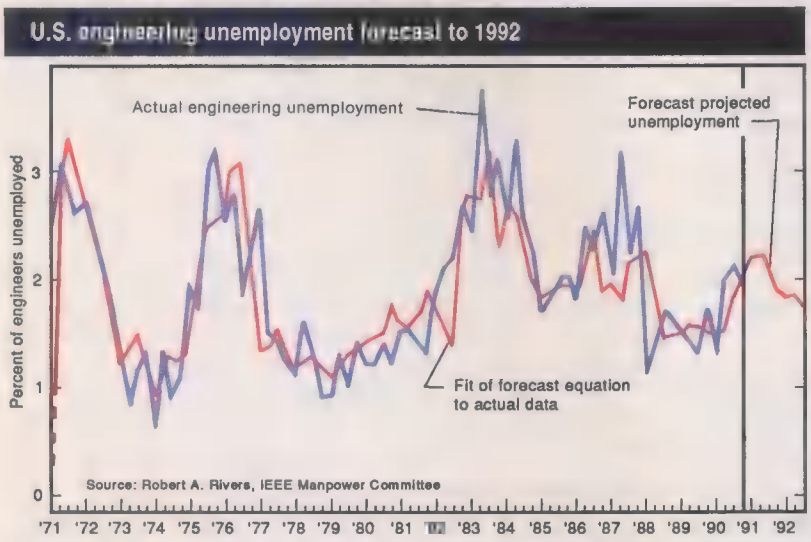
[6] This high-technology recruitment index, by Deutsch, Shea & Evans Inc., a national recruitment advertising agency, is a national indicator of technical demand. It is based on a monthly count of recruitment advertisements directed at four-year-degreed-or-more engineers and scientists and appearing in 38 publications: major U.S. newspapers and technical journals.

by the general economy," Rivers explained. For 20 years, Rivers has drawn on several sources (such as the Deutsch, Shea & Evans high-technology recruitment index [Fig. 6]) to develop a technique for predicting unemployment 21 months in advance. In the 1980s, he said, his forecasts matched reality 70 percent of the time.

"I forecast a peak in engineering unemployment of 2.2 percent in the first quarter of 1991, exclusive of major defense cutbacks or rises in oil prices," said Rivers. "It will go down after that to about 1.7 percent in the second quarter of 1992," he added [Fig. 7]. If defense cutbacks are much deeper than the 3 percent his model assumes, he expects those unemployment figures to be a few tenths of ■ percentage point higher.

For perspective, engineering unemployment has historically been about a third that of the general economy, ranging from a low of 0.3–0.4 percent in 1966, to 3.2 percent during the aerospace cutbacks of 1970, to a high of 3.8 percent in the recession of 1983. In an economy that is neither boom nor bust, engineering unemployment averages around 1 percent.

The fact that defense-related jobs are a minority of high-tech jobs is supported by the analyses of David K. Henry, economist in the Office of Business Analysis of the U.S. Department of Commerce, and Richard P. Oliver, supervisor economist in the Office of Economic Growth and Employment Projections, Bureau of Labor Statistics, and a specialist in defense statistics. In an August 1987 article in *Monthly Labor Review*, Henry and Oliver analyzed data from the DOD, BLS, Commerce Department, and Bureau of the Census, and found that in 1985—the peak year of defense spending—the defense share of all jobs both in Government and private industry reached 6 percent, and defense accounted for 9 percent of all manufacturing jobs [Table 5].



[7] These predictions of U.S. engineering unemployment by Robert A. Rivers of the IEEE's Manpower Committee extend into 1992. Rivers based them on: the Deutsch, Shea & Evans high-technology recruitment index; the monthly figures compiled by the U.S. Bureau of Labor Statistics as part of its ongoing population survey; the Federal Reserve Board's Federal Funds Rate; several econometric models; and estimates of the growth rate of the gross national product.

Much more troubling for U.S. engineers are the economic conditions that are accelerating a trend for companies to downsize—"a management fad largely as a result of foreign competition cleaning our watch for us the last 10 years," said Jerrier A. Haddad, IEEE Fellow and retired vice president of IBM Corp., who has long been active in committees studying issues of engineering education and management. "A good number of reductions are due to cutting central staff functions while maintaining line groups at spartan levels" [Table 4].

The evident implication is "what's good for the general economy is good for engineers," said Marion Anderson, director of Employment Research Associates, a Lansing, Mich., economic analysis and consulting firm. "The majority of engineers work for civilian industries. A shift in Federal spending to civilian priorities involving high technology—the infrastructure, high-speed rail, high-definition television, or other civilian R&D—could generate large numbers of jobs for engineers," more than offsetting the projected loss of military engineering jobs.

"Alternatively, reducing the deficit would cause interest rates to fall," Anderson said. "Lower in-

terest rates encourage private manufacturers to spend money on R&D, new plant and equipment, and all kinds of capital goods—all of which stimulate the hiring of engineers."

Canada and Taiwan: whither thou goest...

Canada appears to be skittering into what some call the first made-in-Canada recession. To blame are the high interest rates maintained by the Bank of Canada to combat incipient inflation. Others point at the new free-trade agreement with the United States, which they maintain whittles away Canada's manufacturing base with a flood of lower-priced goods based on higher productivity and economies of scale.

For example, in October Thermo-Disc Inc., a St. Thomas, Ont.-based manufacturer of thermostats for cars and appliances, laid off 300 employees as the company shifted its manufacturing operations to the United States and Mexico. The company's president, Peter Knight, blamed high interest rates and the strong Canadian dollar. Similarly, Robertson Controls in Etobicoke, Ont., eliminated 150 Canadian jobs in electrical appliance controls. Its president, Martin Champ, cited the "emergence of a North American market" as a factor "in shifting production out of Canada."

Halfway around the world, Taiwan, on the lookout until now for bright engineers for its explosively expanding economy, suddenly finds itself with too few engineering jobs. Overall, Taiwan employs 14 000–15 000 EEs, according to the Council for Economic Planning and Development in Taipei. The island's unemployment rate for all workers is only 2–3 percent and is expected to remain there over the upcoming 6-year national development plan, which will begin next year.

At least for the short term, managers at Taiwanese companies or Taiwan subsidiaries of international companies are being cautious in the face of not only a weak export market in the slowed United States but also the Kuwait-Iraq Persian Gulf crisis. Taiwan imports all of its crude oil, so businesses are vulnerable to an oil price hike. For the time being, spending on some new projects is being curtailed, cutting into plans for expanding staff and temporarily reducing demand for EEs, although there is no evidence that engineers are being laid off.

Japan and Germany: strength in diversity

"Japan is just the opposite of the United States," said Darrel Whitten, vice president and director of Japanese research, Prudential-Bache Securities (Japan) Ltd., Tokyo. There is a labor shortage "not only in the software sector but also in many leading technology segments as well," such as liquid-crystal display panels.

In Germany, no one industry or product dominates the market and the country has a broad industrial base, said Gunter Steinbach, director of technical training at Siemens AG, a company with 40 000 engineers on the payroll. In the past, many small and medium-sized manufacturers could get by without engineers, but not today with the emphasis on automation, Steinbach said.

Steinbach said that the public service enterprises, such as the Bundespost (national mail and telecommunications carrier) and the Bundesbahn (national railroad), have been having problems for years in attracting engineers. One reason is the pay. "If private industry can offer engineers more money and the market continues to be favorable, engineers will continue to seek positions where they can make more money," he said.

France: educational system blocks supply

According to Philips's Faure, the shortage of engineers in France arises in part from "the elitist nature" of the French system of the Grandes Ecoles, the leading engineering schools, which have steadfastly refused to increase the enrollment of students in order to avoid jeopardizing quality. "But the engineers graduating from the Grandes Ecoles are, in fact, generalists—not well adapted either for production or for management," said Faure, "which are precisely where industry has a crying need."

To supplement the high-level engineers graduated from the Grandes Ecoles, the electronics industries have negotiated with France's Ministry of Education to start a new program, called Filiere Descomps, that will allow some 8000 people per year to obtain middle-level engineering credentials through continuing education.

India: low pay aggravates demand

While the Indian Government has made the acquisition of modern technology an overall goal of public policy, creating a tremendous internal demand for engineers, domestic social and monetary problems make it hard for the country to hang onto the engineers it does produce.

Although thousands of private schools for computer education have sprung up all over the country, most are ill-equipped, concluded a 1989 survey by Press Trust of India, the country's largest news agency. "Many faculty positions continue to be poorly paid, resulting in substantial differences in quality among the institutes," said Srinivasan Ramani, director of the state-owned National Center for Software Technology, Bombay. "While some, like the five Indian Institutes of Technology, produce world-class engineers, many others churn out incompetent ones."

Moreover, many of the engineers that are trained end up emigrating—sometimes as much as three-quarters of a graduating Indian Institute of Technology class. Many are attracted to the United States; others go to the oil-rich Persian Gulf states.

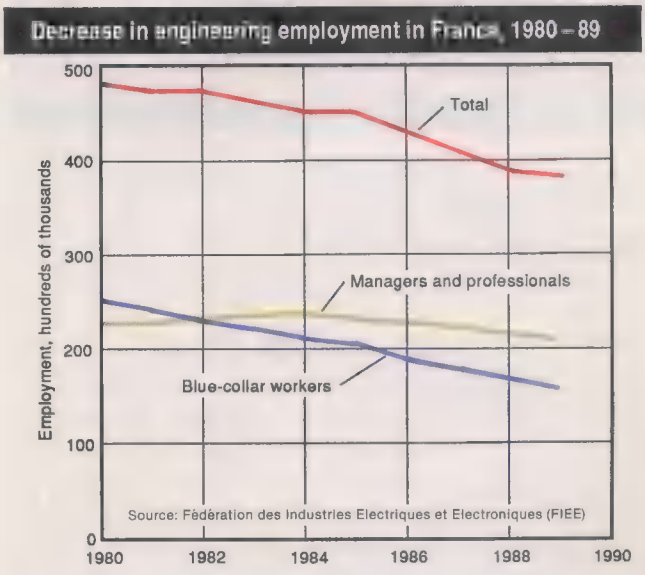
To attract engineers, several top firms have begun recruiting college trainees not just from final-year computer science and electrical branches but from other disciplines as well. But the tendency to train nonelectrical engineers to handle computers creates its own problems. "We've begun facing a perennial shortage of instrumentation engineers," complained Vincent Caszo, senior personnel manager at Uhde (India) Ltd., in Bombay, a subsidiary of Uhde GmbH and one of the biggest engineering consulting firms in the Indian private sector.

Software engineers' salaries average up to three times the pay of other engineers. According to Padm D. Jain, managing director of Mafatlal Consultancy Services, a software consulting firm, "Many instrumentation, even mining, engineers are taking courses and switching to the more glamorous software areas."

Will there be a shortage of EEs?

In bold relief to the gloomy short-term prognoses for engineering employment, analysts in many countries are predicting high demand for engineers by the end of the century.

In Canada, despite a year or more's pain, "the demand for tech-



[8] Engineering employment in France fell steadily throughout the 1980s, though blue-collar workers felt most of the losses.

nical people will increase," said Philip A. Lapp, president of Philip A. Lapp Associates, an engineering consulting firm in Toronto, and president of Radarsat International, a US $400-million project to build and launch a synthetic-aperture radar satellite and to market remote-sensing images.

This demand for engineers will increase "at the same time we are seeing decreased enrollment in our engineering schools," elaborated George Lazano, a spokesman for the Canadian Council of Professional Engineers in Ottawa. Lazano believes that this could lead to a shortage of some 45 000 engineers by 2000.

Similarly, in Taiwan, in spite of immediate problems, most experts still forecast that over the next few years jobs in electro-optics will surge. Firms are ramping up to commercialize electro-optic technology recently developed by the state-sponsored Industrial Technology Research Institute in Taipei. These technologies, including laser printers, laser-driven facsimile machines, and scanners, should begin reaching the market early next year.

In the United States, the strongest prophecies of a shortfall of natural science and engineering (NS&E) graduates since 1988 come from the National Science Foundation's Division of Policy Research and Analysis. In a paper dated summer 1990, the NSF predicts that, based on a "cumulative reduction in production of NS&E bachelors degrees below the average annual number graduated during 1984–86...the cumulative shortfall of bachelors to the year 2006 would be about 675 000" [Fig. 9].

"I don't have much use for shortage predictions," remarked Richard A. Ellis, director of manpower studies for the American Association of Engineering Societies (AAES) in Washington, D.C. In the October 1990 issue of AAES's *Engineering Manpower Bulletin*, Ellis questions how applicable the NSF projections are for engineers because of several of its assumptions: engineers are not separated from natural scientists despite the two professions having different demographics; no allowance is made for changes in the economic outlook that could reduce the demand for engineers; and the 1984–86 benchmark used to judge the magnitude of the projected demand is an all-time historical peak, and thus may be biased on the high side over time.

"Regardless of the state of the economy, there are always going to be surpluses and shortages in certain fields," said Daryl Chubin, a senior analyst for the U.S. Congress' Office of Technology Assessment, Washington, D.C. For example, he noted, despite a drop in the U.S. college-age population, it is possible that the supply of people trained in science and engineering will not decline at all if older people return to school, if a larger fraction of existing students choose those fields, or if non-U.S. nationals continue to represent 25–45 percent of scientific graduate students. He cited a 1985 OTA report, *Demographic Trends and the Scientific and Engineering Work Force*, which concluded: "Given the problems with forecasting supply and demand for scientists and engineers, predictions of shortages based on such forecasts should be treated with considerable skepticism."

5. Estimates of defense-related employment by occupational group for 1977, 1980, and 1985

Occupation	1977	1980	1985
Total (thousands)	1801	2087	2897
Managers	190	224	316
Professionals, technical	240	310	437
Marketing, sales	73	84	116
Administrative support	306	355	490
Services	143	183	261
Mechanics, installers	85	99	133
Precision production	114	134	191
Machine setters, operators	186	194	269
Handworkers	146	174	243
Construction trades	57	58	78
Transportation operators	94	94	125
Helpers	92	96	128
Others	75	83	110
Percent distribution			
Total	100.0	100.0	100.0
Managers	10.5	10.7	10.9
Professionals, technical	13.3	14.8	15.1
Marketing, sales	4.1	4.0	4.0
Administrative support	17.0	17.0	16.9
Services	8.0	8.8	9.0
Mechanics, installers	4.7	4.8	4.6
Precision production	6.4	6.4	6.6
Machine setters, operators	10.3	9.3	9.3
Handworkers	8.1	8.4	8.4
Construction trades	3.2	2.8	2.7
Transportation operators	5.2	4.5	4.3
Helpers	5.1	4.6	4.4
Others	4.2	4.0	3.8

Note: Occupational employment is based upon wage and salary jobs, while industry employment also includes the self-employed and unpaid family workers and is somewhat higher.
Source: David K. Henry and Richard P. Oliver, *Monthly Labor Review*, August 1987

4. Strategies for survival—helping self and company

Clearly, for the next year or so in the United States and Canada, employment opportunities for engineers will tighten. Long-term prospects are not so clear—no one has yet invented an effective crystal ball. Japan, Taiwan, and even Europe—with its booming demand but also massive layoffs—have somewhat mixed short-term prognoses. India seems to be a seller's market.

So, what can you do to cushion yourself and your company in a shrinking economy, and maximize chances for success?

Put not your trust in projections

First, neither an optimist nor a pessimist be about the future demand for engineers—because whole new industries might spring up. "At the beginning of the 1970s, with the aerospace recession, things looked awful, but with the advent of the microcomputer, the end of the 1970s boomed in an unprecedented way," said the AAES Engineering Manpower Commission's Ellis.

Beware especially of predictions of shortages, and thus the overoptimistic demand for engineers, warned the IEEE Manpower Committee's Rivers. "There is no such thing as a shortage in a free-market economy," he asserted. "If a commodity is in short supply, prices get adjusted so supply is rationed out to people who are willing to pay for it." He urged job seekers to look behind the simple numbers. For example, low salaries are one reason that engineering jobs can go begging in the German public sector and in India in spite of high unemployment. If the demand for engineers were as strong as companies and governments say, he cautioned, salaries would rise accordingly.

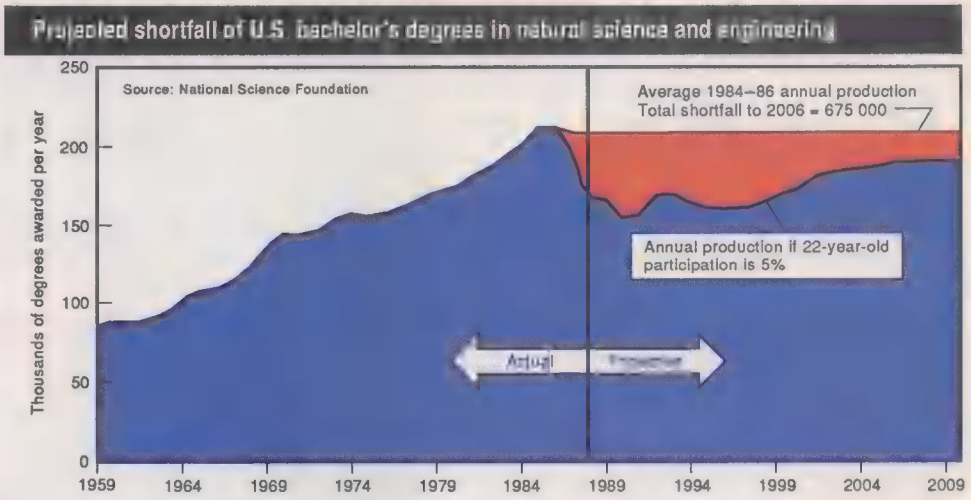
At the same time, do not lose heart over the near-term reports of downsizing, as there is no agreed-upon way of "translating layoffs into unemployment," said IEEE Fellow Haddad. Many people with engineering backgrounds find satisfying work in nonengineering careers, such as finance or education, he noted.

The consensus of all was that young people contemplating an engineering career should base their decision on personal preferences and job satisfaction, not on numerical projections.

Think small

If an engineer is laid off from a large company, he or she "might consider working for a small to mid-sized company," suggested CorpTech's Parker. He attributes the strength of companies employing fewer than 1000 employees to the fact that, with fewer

[9] Because birth rate statistics indicate a decrease in the number of 22-year-olds in the 1990s, there may be 675 000 too few recent graduates in the natural sciences and engineering by the year 2000 to meet demand, according to long-range projections by the U.S. National Science Foundation. (It is assumed that demand will remain at the 1984–86 level.) Engineering students are expected to number about a third of the shortfall.



decision makers, small companies respond better to changes.

If an engineer continues to work for a large company, adopt the mentality of ■ small company, said *Workplace Trends*' Lacey. "Redevelop a sense of urgency about your work," Lacey advised. "Too many people working in large organizations are lulled into the ponderous pace of the bureaucracy, which cuts into productivity, and is one reason that American companies get killed in foreign competition," he said.

Lacey also urged engineers to lobby within their companies "for new approaches to work, such as telecommuting and increased subcontracting." Dispersing work to the lower-cost suburbs can save significant corporate dollars on city real estate.

Consider the world as your oyster

Start thinking of your skills in the context of the world, is another key message from many sources. The Accreditation Board of Engineering & Technology Inc. (ABET), New York City, has begun a program with Canada to let its nationals take the engineering examination in the United States and become licensed in both countries. ABET is also working on agreements with Europe and Pacific Rim countries for cross-licensing. "Countries are leaning in the direction of making engineering a truly international profession," Haddad remarked.

While this trend is fairly new for EEs, civil engineers have been swapping work internationally for years, Ellis told *Spectrum*. The internationalization of engineering is "a topic central to manpower planning and to immigration quotas" of skilled personnel, said Ellis. And the advent of worldwide computer networks that allow international communication and sharing of work also means that engineers "don't have to migrate to compete" with one another for work in various countries, he added.

Nor is this trend unique to the United States. "Japan is also stepping up the 'import' of foreign engineers," said Prudential-Bache's Whitten. "In the area of LCD panels, manufacturers are trying to find human resources in Taiwan and other countries."

"Headhunting agencies are becoming more and more international, to find talent from ■ wider pool to fill ■ given post," said Philips's Faure. He said that Philips has already hired ■ number of U.S. engineers for its VLSI technology facility on the French Riviera, and while "the figures on the paycheck were a bit lower, I think they had no difficulty in enjoying their transfer." He added: "If any of your American colleagues are looking, give them my phone number."

To probe further

Only ■ few sources systematically track layoffs from high-tech companies. One is the semimonthly newsletter *Workplace Trends*, edited by Dan Lacey, Box 16619, Rocky River, Ohio 44116; 216-521-9121. A subscription costs US $48 per year.

The National Science Foundation's Division of Policy Research and Analysis has printed several working drafts since 1988 of its ongoing study, "Future Scarcities of Scientists and Engineers: Problems and Solutions." The most recent one is summer 1990.

The American Association of Engineering Societies' Commission on Engineering Manpower has published several recent articles in its *Engineering Manpower Bulletin*. Richard A. Ellis's most recent article taking issue with the National Science Foundation's scarcity numbers, based on the U.S. Bureau of Labor Statistics (BLS) numbers, is "Prospects for Engineering Manpower" (No. 105, October 1990). It is available from the American Association of Engineering Societies Inc., 1111 19th St., N.W., Suite 608, Washington, D.C. 20036-3690; 202-296-2237.

Robert A. Rivers's projections of engineering unemployment can be found in various issues of *Engineering Manpower Newsletter*, published by Rivers: Box 129, Union, N.H. 03887.

The 1990 report, *Converting the American Economy*, analyzes the impact on jobs by industry and by occupation of annual cuts in the military budget 1991–94 and equivalent Federal expenditures on civilian programs. It is available for US $10 from Employment Research Associates, 406 Hollister Building, Lansing, Mich. 48933; (517) 485-7655.

Among the IEEE position papers on employment-related issues, *Guidelines to Professional Employment for Engineers and Scientists* (3rd edition, Oct. 31, 1989) discusses fair handling of termination of employment.

The German study surveying the demand for engineers based on recruitment advertisements is *Chancen im Ingenieurberuf 90* (Opportunities for Engineers 90), published by Verein Deutscher Ingenieure (VDI), Grafrecke-Str. 84, D-4000 Düsseldorf 1, Germany.

Another study, *Arbeitsmarktbeobachtungen der Fachvermittlung für besonders qualifizierte Fach- und Führungskrafte 1989* (Observations on the 1989 Labor Market for Professionals and Executives), was published June 1990 by Zentralstelle für Arbeitsvermittlung (ZAV), Feurerbachstr. 42-46, D-6000 Frankfurt am Main 1, Germany.

For Japan, *Employment Trends of Science and Engineering Graduates* by Chiaki Nishigata, Akihiro Nakanishi, and Yukihiro Hirano, documents the placement of recent recipients of bachelor's, master's, and doctoral degrees in manufacturing, finance, and other sectors of the Japanese economy. It was published in June 1989 as NISTEP Report No. 1 (National Institute of Science and Technology Policy, Science and Technology Agency, 1-11-39, Nagata-Cho, Chiyodu-Ku, Tokyo, 100, Japan).

Questions of job security in both the United States and Japan were analyzed in *Electronic Engineering Times*' 1990 annual salary and opinion survey: "East Meets West: A look at U.S. and Japanese EEs," Oct. 15, 1990, pp. S1–S82. ◆

This report includes international reporting from John Blau for Germany, Chris Brown for Taiwan, Stuart Dambrot for Japan, Fred V. Guterl for England, Mohan Raj for India, Bradford Smith for France, and Christopher G. Trump for Canada, and additional research by Karl Esch, Alan Gardner, and Wendy Schurr.

Reversing sagging precollege skills in mathematics and science

Efforts to improve curricula, teaching strategies, and the education of teachers and parents are the basis of both new and established programs

A pupil in Newcastle upon Tyne in the north of England investigates why a cut apple turns brown; a class of fourth graders in Dallas signal to their teacher that they understand why one curve is the inverse of the other; and students in Mobile County, Ala., crowd the hallways after school to see whose paper airplane can fly the farthest and straightest.

In Great Britain and the United States, countries where studies show an erosion of student skills in mathematics and science at the precollege level, a variety of programs in these fields is challenging student apathy, improving curricula, and educating teachers and parents. A frequent theme is making math and science more meaningful to students by teaching these subjects in a way relevant to their lives. Below is a sampling of these programs, both new and mature.

Corporate effort

Companies that have had a difficult time hiring technically literate employees have recognized a vested interest in helping schools bolster math and science skills. For instance, a cross section of the U.S. semiconductor industry is supporting precollege education through the two-year-old Semiconductor Research Corp. Competitiveness Foundation (SRCCF). Based in Research Triangle Park, N.C., the foundation receives funding from the Semiconductor Research Corp., a consortium of companies that fund and share results of research at universities.

The program exposes teachers to a diversity of today's newest technologies by taking them on visits to manufacturing and research companies and holding discussions of the theory behind the technologies. The hope is that the teachers will be motivated to develop materials relating the technologies to their course content. This exposure occurs during summer courses lasting five to six weeks.

A typical week consists of 3½ days visiting a technical company to learn firsthand about its products and production-line techniques. A full day is devoted to a visit with a college professor versed in the technology, who spells out the theory behind its development.

"We want to attract youths to science, math, and technology, so they can be informed voters and some will continue toward careers in technology," said Ralph Darby Jr., the foundation's director.

In 1989, SRCCF inaugurated its summer project with 20 high school math and science teachers from seven nearby school districts. The next summer, it expanded the project to New Paltz, N.Y., and Sunnyvale, Calif. Altogether 65 teachers participated.

During Summer Project '90, as this year's program in North Carolina was called, Charles Payne was among 30 teachers who benefited from company tours and university lectures. For the past four years, Payne, who has taught science for 10 years, has presided over physics and applied technology classes at Durham's Northern High School, a suburban institution with 1900 students spanning a wide socioeconomic range. He described a visit to Harris Corp.'s semiconductor-manufacturing facility in Research Triangle Park as especially interesting because "we had an opportunity to talk to the technicians and see the techniques for submicron lithography."

For his physics class, Payne developed material to teach optics by looking at aperture, resolution, and other optical characteristics of photolithography. "I also brought home things like silicon wafers and laboratory videos and photographs to show my students," he recalled. His advanced physics students have also built a numerically controlled robot based on the robotics used at companies he visited.

Another class project, derived from a summer visit to an IBM PC manufacturing plant, is a "production line" for peanuts, used to teach the teenagers how the concepts of statistics apply to quality control. Payne asks his students to weigh each peanut that rolls off the line and then find the variance and standard deviation of the peanut weights.

To ease the exchange of ideas with one another and with industry and university members of SRCCF, each participant was lent a personal computer and a modem for a year by IBM Corp. and Microcom Inc., Norwood, Mass., respectively, for electronic networking. After a year, if the foundation finds that the equipment has been a success, the teachers may keep the PCs and modems.

Payne uses his PC, modem, and an 800 number to network with other program participants in North Carolina and New York. (California teachers are not on-line yet.) "We now can have 'conversations' with each other, instead of having to leave messages on a bulletin board," he said. "In January, February, and March, when it's gray outside, it's nice to be able to get an uplift to pull yourself through the trials and tribulations of teaching."

In Sunnyvale, Calif., the SRCCF Industrial Problem Solving project enabled 14 teachers to visit Hewlett-Packard Co., Intel Corp., Tandem Computers Inc., and Westinghouse Electric Corp. Margaret Szady, the newly appointed math department head of Monta Vista High School in Cupertino, was an SRCCF Fellow this summer. "There aren't that many low-level jobs anymore," said Szady after her visits. "Many employees, even salespeople, have EE or ME degrees."

Her message for this suburban upper-middle-class school of 1750 pupils: if you want to find a job in this area, you'll have to know more about technology. The companies she visited recommended that all high school students take physics and math through calculus.

Szady was also struck by the companies' frequent use of teams to solve problems and, therefore, has decided to incorporate them into class projects, assigning just enough students to each team for everyone to be able to contribute toward the project. She also plans to incorporate an assignment from her SRCCF summer into an interdisciplinary program in which Algebra II students de-

Katherine T. Chen Associate Editor

0018-9235/90/1200-0044$1.00©1990 IEEE

Secme

Marco Howell, a student from Southwest Dekalb High School, Decatur, Ga., won the regional Mousetrap car, Poster, and Essay Competition sponsored by the Southeastern Consortium for Minorities in Engineering (Secme).

sign a rollercoaster, history students delve into the origin of the machines, English students make oral presentations about that subject, and physics students look into the dynamics of carts hurtling people up and down mountainous tracks.

Six other states have requested similar programs. Next summer, SRCCF may add sites in Arizona, Colorado, Florida, Idaho, Massachusetts, and Texas.

A regional solution

Another program that receives industrial support is the Southeastern Consortium for Minorities in Engineering (Secme). It demonstrates effective classroom strategies to high school teachers in summer workshops and provides them with supplementary course material. Established in 1975 by regional deans of engineering, it is designed to encourage minority students to study mathematics and science in middle and high school and eventually enroll in engineering in college. While defining blacks, Hispanics, and American Indians as minorities in engineering, it also welcomes nonminorities.

Secme is the product of a national effort by chief executive officers who sought to increase the number of upper-level black managers, a large percentage of whom, they recognized, come from engineering backgrounds, said Carolyn Chesnutt Thorsen, 1976–89 executive director. In 1971, only 400 black engineers were graduated from colleges nationwide, she said. The managers realized that 15–20 years later, only a similar small pool of people would be available to be upper-level managers, she said.

Secme got off to ■ running start with a US $1.1 million grant from New York City's Alfred P. Sloan Foundation. Thorsen, now a consultant for Georgia Institute of Technology in Atlanta, Ga., was instrumental in obtaining that funding, which lasted until 1981. By then, Thorsen, who remembers visiting 110 corporate headquarters in 2½ years, and others had wooed and won support from the business community. Secme funding from industry reached US $300 000 out of a total US $750 000 in the fiscal year ending June 30, 1990.

Representing 28 universities and 65 corporations, Secme serves eight states: Alabama, Florida, Georgia, Kentucky, Mississippi, North and South Carolina, and Tennessee. Its headquarters are the campus of Georgia Tech. Some 18 000 minority and 3000 nonminority students attend secondary schools in systems that have asked to participate.

Secme teachers take two-week courses for academic credit, held every summer on a different college campus. They learn to link science, mathematics, and English material to real-world applications and to enrich the curriculum using the microcomputer as a teaching tool. "If you train the teachers, they will have a multiplier effect on the students," said R. Guy Vickers, Secme's current executive director. The program measures its success in terms of the 1300 teachers trained in its workshops since 1977.

In spring 1990, out of 4385 Secme students graduated from high school, 85 percent went on to college. Of these, 46 percent are studying engineering. Vickers plans to begin tracking these students and Secme alumni to obtain data on college retention, which colleges students attend, and which companies they end up working for. (The followups were not done in earlier years because Secme has been funded primarily to help teachers.) Funding is still a problem today, but word-of-mouth has already prompted alumni to call. Vickers plans to ask these alumni to serve as role models and help start scholarship programs.

Secme identifies students with an aptitude for mathematics in the sixth or seventh grade on the basis of teacher recommendations, standardized test scores, subject performance, or interest in the program. Early intervention is important because youngsters must be reached before they enroll in algebra—generally in the seventh or eighth grade—a major obstacle to more advanced mathematics for many students.

Each participating school system has a project director, and each school has a Secme team (usually composed of a mathematics, science, and English teacher, and ■ student counselor). Together they advise students, encouraging them to complete: mathematics through trigonometry; four years of college preparatory science, including chemistry and physics; and four years of college preparatory English courses.

In Mobile, Ala., Vangalia Kordomenos, a Secme director and an assistant superintendent for the Mobile County Public School System, oversees 2000 Secme students in 24 middle and high schools that have a total enrollment of about 25 000 students, nearly half from minority groups. Like students in the other systems taking part, Secme pupils there enter ■ number of contests designed to build interest in engineering. The school's winner joins other local winners at an annual regional competition held on the campus hosting the teachers' summer workshops. Cash prizes are awarded to three finalists.

For example, in a Mousetrap Car Competition each year, students use a mousetrap to try building the shortest and lightest car that will travel the longest distance. The competition also includes poster and essay contests on separate topics.

Another competition, Kordomenos noted, requires students to create a container to catch an uncooked egg dropped 20 feet (6 meters). "The egg must land without cracking, and excess size and weight [of the container] will count against them because, in business, it costs money," she said. The real-world inspiration for this competition, she added, was the design of the space shuttle for safe return to earth.

Teachers in the Semiconductor Research Corp. Competitiveness Foundation's (SRCCF) Summer '90 Project tour the automated manufacturing line at IBM Corp.'s PC manufacturing plant in Research Triangle Park, N.C.

Last year's Secme Teacher of the Year, Leevones Johnson, was overseeing one of her school's monthly contests when *IEEE Spectrum* interviewed her. In this competition, students fold a letter-sized piece of bond paper into an airplane and see who can fly it the farthest. If the plane veers from the "runway," a marked line, that distance is deducted from the total distance the plane has flown.

The school's science department head, she has taught science at Blount High School in Mobile County, Ala., a school with a predominantly black student population, for three of her 19 years in teaching. Known as a "spark plug" teacher, she has drawn 19 other teachers and one counselor into the Secme team. Together they plan summer field trips to museums, universities, and research centers; invite engineers and professors to speak; cajole companies into providing materials for the monthly student contests and other projects; and advise the program's 221 students on course selection.

"Last spring all 22 Secme seniors got acceptance letters from colleges, said Johnson, "and four received scholarships from engineering schools."

Planting SEEDs

Project SEED, which predates Secme, teaches supplementary math at schools with mostly minority students to children in the fourth, fifth, and sometimes sixth grades. Its goal is to give students from underprivileged backgrounds the confidence not only to think through mathematics problems but to face other hurdles in life, too. SEED instructors teach advanced mathematics, mostly algebra and calculus, as a supplementary hour to the students' regular mathematics class four days a week.

The program was founded in the 1960s in Berkeley by William Johntz, a mathematics teacher who died in 1988, and spread from California to other states, where the programs flourished, then floundered after Federal funds were cut in 1980. Today, Project SEED has taken root in Philadelphia and Dallas as well as Berkeley.

"Mathematics was chosen because it is prestigious and most people are afraid of it. So, if you do well in it, then you are considered successful," said Hamid Ebrahimi, national resource and development director at the Project SEED Inc. headquarters in Dallas.

The program requires its instructors to have at least a college degree in mathematics or an equivalent, such as physics or engineering, because only someone with a deep understanding of the subject can comfortably field youngsters' sometimes unorthodox questions.

SEED teachers use the Socratic method to encourage students to think and to prove their assertions. Students are praised even for ideas that prove wrong, because here it is literally the thought that counts. The regular math teacher also attends SEED classes to learn teaching techniques and obviate certification of SEED teachers by the state.

SEED instructors must undergo at least two months' training to teach one class, and a year's to teach four—a full course load. They are observed and critiqued by colleagues at least once a week and must attend after-school workshops in mathematics, psychology, and teaching methods three times a week.

An evaluation by the Dallas district in 1988 concluded that SEED instruction had a beneficial short- and long-term impact on mathematics achievement. SEED students performed better than the rest in their regular mathematics classes, more of them enrolled in advanced courses in middle school and early high school, and fewer of them failed to be promoted.

Mobilizing engineers and scientists

In contrast to SEED instructors, engineers and scientists who serve as second-career teachers in a National Executive Service Corps (NESC) program become state certified [*Spectrum*, August 1987, pp. 28–31]. Established in 1986, the program has helped 200 retired or about-to-retire engineers and scientists from 10 private-sector and military sites study toward certification at nearby colleges and universities. About half are now teaching and the remainder are completing credits. Because many have advanced degrees or even some education credits, they require only 6–15 months to obtain the necessary teaching prerequisites.

NESC, which is located in New York City, asks each candidate's state board of education to define how many credits he or she needs to qualify for certification. Then it finds a teacher's college or university willing to admit them. "We try to put them in support groups of 10–20 so they won't be alone in a class of only younger students," said Donald Black, president of NESC's math/science education group.

Four NESC alumni are now teaching in the Ft. Worth Independent School District in Texas, after completing education credits at Texas Christian University, also in Ft. Worth, and a one-year internship. The newly certified instructors have brought energy to the three schools where they teach, according to Gwen Morrison, a director in the school district's personnel department who oversees the teacher certification program.

NESC teachers are paid the same starting salary as other teachers. In the Ft. Worth School District, the starting salary was US $21 000 during 1989–90. However, money is not the primary motivation for many of the retirees, who tend to have pensions, individual retirement acccounts, and other investments. "They're doing this because it's a way for them to give something back to the community," Morrison said.

At Arlington Heights High School in Fort Worth, F. Gene St. John, a retired General Dynamics Córp. electrical engineer who worked on nuclear bombs teaches 11th and 12th graders the application of basic computer programming to the solution of math problems.

Now in his second year as ■ teacher, St. John, aged 60, has found the teaching experience bittersweet. "What was startling was the enormous amount of time that schoolteachers must expend to find out what kids are like, what works in the classroom today but not tomorrow, and what's appropriate to meet state requirements," said St. John. During his first year, he spent 95 hours a week teaching, compared with 40–50 hours a week at General Dynamics. This year he is working about 80 hours a week. The 30 hours' worth of observation that he and other teachers had before their internship was not sufficient, he said.

Another problem with teaching is what he calls the "national difficulty of kids not wanting to learn." Although the courses he teaches are electives, he feels that most students take them to satisfy high school graduation requirements rather than out of interest. "They do what they need to do to get the grades to go to college," St. John said. "Only ■ few show a high level of interest in learning for learning's sake."

On the other hand, he has enjoyed interacting and sharing his experiences with the students at this predominantly white school of 1400. "I enjoy the looks on their faces when they understand," he said.

Although St. John wanted to teach for many years, he delayed doing so until he was financially secure. Despite his ambivalence, he thinks the alternative certification program is sound, because it gives people like himself a chance to teach and allows school systems the opportunity to replenish the math and science teachers who leave for industry each year because of their meager teaching salaries. And he does have a gripe: "In my opinion, if school districts expect to bring in people from industry, higher compensation for their experience is only logical."

When funding from the National Science Foundation, the U.S. Department of Education, and Carnegie Corp. of New York City ends this year, NESC, a nonprofit management consulting firm, plans to remain a repository for the experience acquired over the past years so that other local groups can continue to tap their techniques.

Involving the family

While most ventures intended to help children improve math skills focus on teachers, pupils, or curricula, the Family Math program reaches out to parents. Established in 1981 at the Lawrence Hall of Science at the University of California, Berkeley, with U.S. Department of Education funding, Family Math provides workshops that are primarily for minority parents and children but are also open to others. The activities are designed for children in kindergarten through the eighth grade.

"With reading, parents and kids put their arms around each other and read in front of the fireplace before bedtime," said Virginia Thompson, director. "Math never got the same feeling created around it."

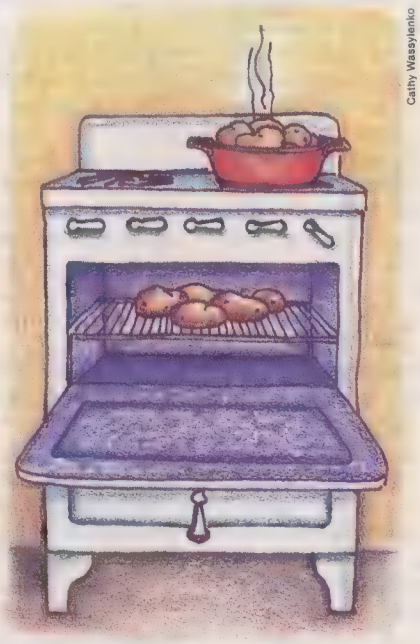
At the workshops, parents learn about math-related activities that they and their children can share at home. In one, each successive letter of the alphabet from "A" on is assigned a monetary value of US $1–$26. Each member of the family then figures out, say, the dollar value of his or her first name, someone in the group whose name is worth US $5 more than his own, ■ word that is worth exactly US $100, and solutions to other quantitative problems.

Another activity, described in the workbook that each workshop participant receives, teaches players to discover a winning strategy. Ten toothpicks are laid out on ■ surface, and each player must pick up one or two when his turn comes. The one who picks up the last wins.

"Parents now realize that math can be fun at home," Thompson said. "It doesn't have to be just practicing long division over and over again."

For 1½ years, the program was taught in pilot classes in communities in the San Francisco Bay Area with a high percentage of blacks and Hispanics. Family Math workshops have been offered in 48 states (17 sites have regular meeting classes); throughout Australia and New Zealand; in Toronto, Canada; and in Lund and Luleå in Sweden, according to Thompson.

Under Equals, ■ teacher in-service program concerned with helping students stay in math when it becomes optional in high school, Family Math receives funding from the National Science Foundation and the State of California, in addition to the U.S. Department of Education. "Our long-term goal is to work on ways to reach more parents who are disenfranchised," Thompson said. A recent spinoff is *Matématica para la familia* for Hispanics who speak limited English. Another spinoff focuses on science for the family.



Cathy Wassylenko

Bodil Jonsson, a Swedish educator, has devised this and other problems that are relevant to daily life for high school science students: why does it take less than half an hour to boil potatoes, where the water is 100 °C, but an hour to bake them at 250 °C?

Tying in the real world

Instead of training parents and teachers, two British programs have developed curricula that provide activities stressing the relevance of science to the rest of life.

One, Salters' Science Project, has developed curricula that spell out step-by-step exercises. Based at the University of York, the project introduces science by discussing applications before theoretical principles. The materials, written initially for 14–16-year-olds, are being used in 140 British schools with 15 000 students.

For instance, the module about communication looks at the impact of satellites, fiber optics, and other technological developments on communication systems and at how the electromagnetic spectrum fits into the picture. Another module teaches students how important it is to understand electricity in order to use it safely in the home; the unit covers power, wiring, circuit loading and overloading, and portable sources. A third science unit explains kinetic and potential energy in terms of sports activities.

"We don't get titles like 'Kinetic Theory' or 'Electromagnetic Spectrum'; instead we

have 'Drinks for Keeping Healthy,' " said Peter Nicolson, project officer. The teaching units also favor everyday materials such as "lumps of mud or an old Army blanket" instead of a laboratory chemical such as copper sulfate.

At a cost of US $750 000, 45 volunteer teachers and a management team of 15 toiled for three years on the curriculum. The units have been tested by 1200 teachers in 450 schools over a year and a half. Funding came from the Salters' Co. of the City of London (formerly a guild for salt importers but now a foundation) and other groups. The Salters' curriculum was accepted by the Midland Examining Group, one of four influential national groups that propose their own syllabuses and draw up an examination that meets national criteria.

Such popularization has finally overcome objections that "you can't teach good science and popular science," Nicolson said. "At the end of the program, we want more children interested in science and confident that they can understand it."

One of the schools using the curriculum for eighth and ninth graders is Rutherford School in Newcastle upon Tyne, in a former coal-mining region that heavy industry now dominates. The school's 1300 students come from middle- and lower-class families, and its buildings and laboratories need refurbishing. When Brian Kerry was appointed head of science two years ago, he was determined to rouse apathetic students to enthusiasm. "I looked for a way to teach students science that would have immediate attraction—that would be fun for them to do and something they could see they were achieving," said Kerry, who formerly taught only biology but now teaches a wide range of science subjects.

He and his 13 colleagues reviewed all available curricular material and found a few they saw as student-centered; among these, they thought Salters' was the best. One strength is that it provides extensive teaching notes, allowing teachers to extend the topic from one discipline, say, biology, to another, such as chemistry, even if they may not feel fully at ease with a subject outside their area of expertise.

An example of its down-to-earth approach is the unit about enzymes currently being tried out with 10th graders. A traditional curriculum would deal with the chemistry of enzymes and perhaps provide a textbook example of digestive enzymes. Instead, students are asked to look at enzymes in terms of apples. In the first part, they are asked why cut apples turn brown. In the next, they play scientific experts invited by a company to investigate pectinase, an enzyme that causes cells to rupture. "Could you recommend a way to make more juice out of apples?" a teacher might ask. The students proceed to carry out an enzyme experiment on apples and then produce a scientific report.

According to Kerry, "The pupils were saying, 'Can I take this [Salters' module] home and do some more work?' or 'Could we try this?' " He and colleagues are expanding the Salters' curriculum to the 10th and 11th grades.

Kenneth Whitehead, a school board member who has two children taking Salters' science courses, observed a class at Rutherford and was pleased. A design and operations engineer for power plant generators at Northern Engineeering Industries Parsons Ltd. in Newcastle, he said, "From the pupil's viewpoint, it's taught in a much more comprehensible way. The principles are there, but the lead-in is very practical."

Another contribution to student motivation was Kerry's elimination of all but the top of five sets, or classes, in each grade that were selected by ability. The four others each have students with a range of abilities.

At least one student has been more grudging in his support. According to York University's Nicolson, a student wrote the Salters' group: "I didn't learn very much in these lessons, but I learned more than I usually do."

Societal implications

Another British group, sponsored by the Association for Science Education in Hatfield, has produced a supplementary curriculum that shows students not only how relevant science is to daily life but how it and technology can help or harm society and the environment. Called Science and Technology in Society (Satis), the group's instructional material has been adopted in about 50–60 percent of schools in England and Wales, according to John Holman, project director. About 120 hour-long modules have been developed for students in the 14–16 age bracket since 1986.

"We have influenced examination curricula and textbooks," Holman said. Furthermore, the Satis units have been translated into Italian, Swedish, Dutch, and, in part, Chinese for use in Hong Kong. "Although the units are to some extent culturally dependent, it's surprising how the Italians and others have adapted the modules for their own use," he said.

The group hopes to change students' attitudes toward science courses by humanizing them, especially with girls in mind. "Lots of girls have opted out of science," said Holman, a senior teacher at Watford Grammar School, a high school near London. "We need to motivate all students more because after the age of 16, they have the option not to study science."

Topics encompass industry, agriculture, the environment, and health. Some of the units cover fluoridation of the water supply, DDT and malaria, clothing fibers, blindness, energy sources, and survival with simple technology. Students take part in role playing, discussions, data analyses, and other activities.

For example, in the unit about dams, they are presented with the problem of balancing the need for electric power against the environmental effects of a dam and reservoirs. Working in groups, they are then asked to assess the environmental impact of three different hydroelectric power plants. In each group, one student assumes the role of an ecologist, another a land-use consultant, a third a sociologist, and a fourth the Minister of Energy who makes the final decision.

To accommodate instructors who are reluctant to use more adventurous teaching methods, some Satis modules give only traditional assignments such as comprehension exercises. In explaining such teacher resistance to innovative teaching approaches, Holman said, "They feel they are taking risks. They may lose control of the class or fear that the students won't be capable of it."

Holman and other teachers believe that the Satis approach, which asks students to think in a "divergent open-ended way" instead of the traditional convergent method, can involve those students who are accustomed to failure in science. "Sometimes, there is no right or wrong answer, and everyone has a right to an opinion," he said.

Satis's first science module was written by a team of 30 teachers for 14–16-year-olds and tested in the field by 100 teachers. The initial total budget was £200 000, provided primarily by the Gatsby Foundation in London. This year, Satis has published 75 modules for 16–19-year-olds and is planning modules for students between ages 8 and 14.

To probe further

For related information, see "Why most U.S. students can't get into engineering school," by Kimberly Pyko in the August 1987 issue of *IEEE Spectrum*, pp. 28–31. In November 1984, *Spectrum* also published a special issue on engineering education.

J.L. Lewis is the author of one of the earliest articles about the societal implications of science. His article "Science in Society" appeared in Vol. 5 of *New Trends in Integrated Science Teaching*, Unesco, 1979.

Information about British projects can be obtained from two sources: Satis, Association for Science Education, College Lane, Hatfield, Herts, UK, and Salters' Science Project Science Education Group Department of Chemistry, University of York, York, UK.

U.S. engineers and scientists may refer to the IEEE-USA pamphlet, *Directory of Volunteer Opportunities in Precollege Mathematics and Science Education*. Contact: IEEE-USA, 1828 L St., N.W., Suite 1202, Washington, D.C. 20036-5104; 202-785-0017. ◆

Whistle-blowing: not always a losing game

Five engineers in nuclear power, aerospace, and air-traffic control recount their experiences in following their consciences

Exposing errors or unethical conduct in any occupation is risky, but when engineering judgment is involved, the risks of "blowing the whistle" acquire an added dimension. A technical decision cannot always be categorized as strictly right or wrong—unlike situations in which an organization is falsifying documents or overcharging for a product. Consequently, the engineer must be convinced of being right and then wait, sometimes years and even decades after lives are lost or millions of dollars are spent, to be proved right or wrong. Frequently, the whistle-blower's career is destroyed in the meantime.

In the following cases, which date from the 1970s and 1980s, the whistle-blowers have by now been vindicated to a degree for their actions, though the verdict may not be unanimous. And the careers of the first group may have even benefited by blowing the whistle.

NUCLEAR POWER, FEBRUARY 1976

Three engineers quit General Electric Co.'s nuclear division to protest alleged inadequate testing and unsafe designs, not only at GE but throughout the nuclear industry.

Though engineers Greg Minor, Richard Hubbard, and Dale Bridenbaugh expected that their decision to resign their jobs might get some attention in the newspapers, they thought it would play itself out in a few days. The day after they quit, however, they realized their lives had irrevocably changed when they were thrust in front of hot lights, cameras, and reporters at a press conference in Los Angeles.

"We're technical people," said Minor. "Our lives changed because we had to become political people—not because we wanted to, but to keep the debate focused on the technical issues."

The three engineers were able to continue practicing engineering and have fared much better than most whistle-blowers. Nine months after resigning from the San Jose, Calif., GE division, they started a successful consulting firm on nuclear power, MHB Technical Associates, also in San Jose.

Each of the GE engineers came independently to his decision to resign, but agreed to do it together publicly in order to have more of an impact on the debate over nuclear power, which at that time was raging in California because of Proposition 15, an initiative requiring that certain safety problems be resolved before more nuclear plants were licensed.

Rude awakenings

With a bachelor's degree in mechanical engineering, Bridenbaugh went to work for GE in 1953 and was ■ start-up supervisor in 1960 at the world's first commercial boiling-water reactor at Dresden Nuclear Power Station, in Morris, Ill., near Chicago. After the plant had been in operation a short while, Bridenbaugh said failures began occurring that the designers had not foreseen; pumps stopped working, heat exchangers leaked, and control rods started warping, bending, and cracking. "The reactor began falling apart," he said. "The designers really didn't understand what they were dealing with."

The final straw came when Bridenbaugh, as manager of nuclear reactor performance improvement, reviewed reactor containment response to possible accidents. A computer simulation showed that 19 GE plants in operation in the United States might not survive ■ serious accident: the release of pressure during an accident would throw up a violent swell of water that the containment could not withstand, possibly resulting in the release of radioactivity into the atmosphere.

Refusing to believe the simulation results, Bridenbaugh's manager wanted to keep the plants operating; he told Bridenbaugh that if they had to shut down, it would be the end of GE's nuclear business. In his last major task at GE, Bridenbaugh and other GE engineers met with the utilities to convince them they had to spend millions of dollars on plant modifications, but the utilities representatives refused, saying that they did not have the authority to make the decision.

Minor began working in GE's San Jose division in 1960. He received ■ master's in electrical engineering from Stanford University in 1966, and took part in designing the routing of the electrical cabling at the Brown's Ferry plant in Decatur, Ala. It was the first one to incorporate safety requirements increasing the separation of redundant cables. "I thought this was the best plant we had designed," he said.

But the cables were sealed with flammable polyurethane foam, and in 1975 when technicians performed ■ routine check for air leaks with a candle, the sealant caught fire. Because of about half a dozen mostly human errors, the fire raged for seven hours, damaged 1600 cables, and disabled most of the emergency core-cooling system. The core came close to being uncovered, but the crisis ended when an auxiliary pump was used to dump water into the reactor. "To me it was a disaster," said Minor. "I felt we were very, very lucky we hadn't had a major catastrophe."

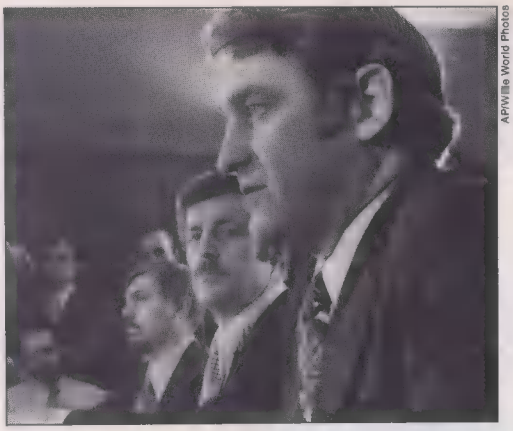
Richard Hubbard, who began working for GE in 1960 with a degree in electrical engineering from the University of Arizona, was also disturbed by the Brown's Ferry accident. But as manager of manufacturing quality assurance for the nuclear division, he had already seen what he regarded to be fundamental problems with the company's attitude toward safety. While trying to eliminate a serious vibration in the reactor core, GE engineers stumbled upon a miscalculation in the core-cooling system flow rates and realized that the water would not flood the core as quickly as expected during an accident. When told of the problem, "a GE vice president said, 'It's important when you look under a rock, the angle that you look,'" Hubbard recalled. "He meant to look straight under the rock—don't look around and find other problems."

When the engineers quit, they made a point of not criticizing

Karen Fitzgerald Associate Editor

0018-9235/90/1200-0049$1.00©1990 IEEE

Engineers Richard Hubbard, Greg Minor, and Dale Bridenbaugh (at right) testify in 1976 on safety problems with nuclear plant designs before the U.S. Congress Joint Committee on Atomic Energy, where they encountered hostility and skepticism. Shown (below) in happier times, Minor, Hubbard, and Bridenbaugh discuss a nuclear plant study at their consulting firm MHB Technical Associates, San Jose, Calif.



AP/Wide World Photos

Cindy Charles

any person or the company specifically, but focused on the issue, which for them was that there were fundamental safety problems that the industry and the Nuclear Regulatory Commission (NRC) had not addressed adequately. They felt that there was too much reliance on theoretical models and not enough prototype or field testing. "The rate at which nuclear power was developed outstripped our knowledge and our understanding of the consequences and the side effects," said Minor. "All we were saying was 'Let's slow down and look at the side effects.'"

Testifying in Washington, D.C.

After their resignations, phone calls began flooding in from around the world for interviews and information about nuclear power. The engineers were asked to meet with commissioners of the NRC, who, the engineers believed, seemed more interested in undercutting their position than in understanding the technical reasons for it. Two weeks after resigning, they testified before the Joint Committee on Atomic Energy in Washington, D.C., where they again encountered skepticism and harsh questioning. Physicist Edward Teller and others accused them of being paid by the Soviets to speak against nuclear power.

GE disputed the engineers' views on nuclear power, and today still believes that their resignations were part of a preplanned publicity campaign to influence the Proposition 15 vote. "The resignation letters presented no fresh views or arguments but repeated the emotional claims of an antinuclear group of which they and their families were apparently members," GE spokesman Hugh Hexamer told *Spectrum* in a written statement.

Among their consulting firm's first projects was campaigning for initiatives similar to California's Proposition 15 that were on the ballot in six other states that fall. They also began a safety assessment of the Diablo Canyon Nuclear Plant in Avila Beach, Calif., for the Center for Law in the Public Interest, which was supporting intervenors in the NRC licensing process.

That year, the Union of Concerned Scientists hired them to write a formal critique of the WASH-1400 risk assessment study, which estimated the probability of a core meltdown. The Swedish Government in 1977 asked them to perform a similar risk assessment for Sweden's nuclear plant at Barsebäck.

In 1978, the firm was asked by movie actor and producer Michael Douglas to devise a technically accurate scenario for a feasible nuclear reactor accident for *The China Syndrome*. For two weeks after it opened, MHB spent most of its time defending the sequence of events portrayed in the movie. After two weeks, the Three Mile Island (TMI) accident occurred in Pennsylvania, with many of the same precursors as the movie's scenario, but it went a step further to a partial coremelt. The press now began asking them to explain what happened at TMI.

The TMI accident gained credibility for MHB's views, and in addition to doing safety studies for intervenors in the licensing for the Shoreham nuclear plant, Brookhaven, N.Y., and others, the firm was hired by state attorneys general and utility regulatory agencies concerned about the economics of nuclear power and the prudence of rate increases.

The firm recently conducted a study of advanced reactors for the Union of Concerned Scientists, putting the engineers in the news again—and back in the position of being pitted against at least some in the nuclear industry. While MHB found that many of the features of the new reactors improved safety considerably, the engineers are concerned that the designs introduced new vulnerabilities not yet adequately explored, and that, despite these weaknesses, the nuclear industry and the Department of Energy are promoting them as inherently safe.

It seems that the three engineers are still blowing the whistle. Undeterred by the difficulties they encountered, they all say they would do it again. "The only regret I have," said Bridenbaugh, "is the hard feelings that developed between the people I worked with for many years who apparently don't understand why I had to do this."

AEROSPACE, JANUARY 1986:

Engineers at Morton Thiokol Inc. warn against the launch of the space shuttle Challenger because low temperatures predicted for the next morning might stiffen O-rings. The launch proceeds as scheduled, and seven astronauts die in an explosion caused by the O-rings' failure to seal rocket booster joints.

Like the GE engineers, mechanical engineer Roger Boisjoly was one of three who spoke out against a management decision at his company, Morton Thiokol Inc. (the aerospace division is now Thiokol Corp.), Brigham City, Utah. However, in his case, Boisjoly found little advantage in numbers. After six years with the company, he lost his job, and despite a 27-year career in the industry, could not find another. His two former colleagues have fared somewhat better—both have retained their jobs at Thiokol, even though apparently derailed from the fast track.

Boisjoly explains the uneven outcome by what transpired in the hearings of the President's commission investigating the shuttle disaster. The company instructed the engineers to give only "yes" and "no" answers and to volunteer nothing. Boisjoly spoke first and "bared all," revealing that the engineers warned that the cold temperatures—a low of 18 °F (-8 °C)—predicted overnight before the morning launch might render the booster O-rings

so stiff that they would be unable to seal the gases properly. He and Thompson presented evidence of a past launch at 53 °F in which one of two redundant joints had not sealed.

Thiokol's upper management initially would not approve a launch below 53 °F, Boisjoly told the commission, but they later buckled under to pressure from the National Aeronautics and Space Administration (NASA), which had already postponed the launch four times. NASA argued that no launch criterion had ever been set for the booster joint temperature. Allan McDonald, the only Thiokol manager at the Kennedy Space Flight Center where the launch took place, fought against the launch to the end.

Although McDonald and engineer Arnold Thompson volunteered information during the commission hearings, Boisjoly believes that their 25 years with the company, compared with his six years, gave them more job security. Furthermore, Boisjoly was singled out for harsh punishment because of his outspokenness, he said. He saw his ultimate transgression as challenging testimony at the commission's public hearing by the company's general manager, who said that no unanimous engineering position against the launch had existed the night before. "That simply was not true," Boisjoly told *Spectrum*. "By telling the commission that, I put myself further and further in the quicksand. When I left that meeting, I knew I was at the top of the hit list."

Growing isolation

Shortly afterward, the company took Boisjoly off the failure investigation team and sent him back to Utah, while Thompson remained on the team in Washington. Boisjoly was assigned to work on the redesign of the booster seal, and although told he was very important to that redesign effort, began to realize he was being left out of meetings. When questioned a couple of months later by the President's Commission looking into whether the Thiokol engineers' jobs had been affected, U. Edwin Garrison, president of Morton Thiokol's aerospace operations, said he had given an official order to isolate Boisjoly in order to minimize friction with NASA.

But Boisjoly believes the real reason was that management did not want a thorough redesign. "I truly believed them when they told us as engineers that we were going to have a clean sheet of paper to redesign these joints, to do the job right." He said he was "devastated" when he realized that management itself had devised a redesign only marginally different from the original in a strategy to fend off outside criticism of the failed design. All management wanted the engineers to do was make the design work, he added. "I really cared about the program," he said. "I had devoted my whole being to doing the best possible job I could do, and when I found this out, it just destroyed me."

Furthermore, he and four other engineers who testified before the commission were feeling heat from co-workers who viewed the group as troublemakers out to hurt the company. Formerly close associates turned away when meeting them in the corridors and would not speak to them.

Boisjoly soon began experiencing stress-induced symptoms, including double vision and pains in his chest and shoulder. After going on sick leave for six months, he was diagnosed in the fall of 1986 as having post-traumatic stress disorder, qualifying for long-term disability benefits. But when the benefits took effect in January 1987, the company terminated his job.

Since that time, Boisjoly has given more than 100 talks on his experience to students, professional societies, and businesses. Anticipating that he might have trouble finding another job, he studied for a professional engineering license so that he could become a consultant. In prior job searches, he had to decide among two or three offers, having had experience at companies including Hamilton Standard Electronics Systems Inc., Atlantic Research Corp., and Rockwell International Corp., but this time he received only one job interview after sending out 150 resumes. In March of last year, he started a consulting business in Mesa, Ariz., to provide expert technical testimony in legal cases.

Although this past year his fees match the salary he received in industry, Boisjoly is bothered by his income's instability. He filed a lawsuit against Morton Thiokol for compensation for "ruining his career," but the case was dismissed by a Federal judge in Utah. "People who are branded whistle-blowers have no rights," Boisjoly said. "The Whistle-blower Protection Act was passed in 1989, but it only deals with Federal employees. I was trying to make the law with my lawsuit."


Will Jones

Engineer Roger Boisjoly works in his office at home where he now does technical consulting for legal cases.

Arnold Thompson and Allan McDonald are still at Thiokol. Thompson is now working on the manufacturing side of the shuttle program, instead of engineering analysis, and McDonald is off the shuttle program altogether, with the title of vice president of special projects. Thiokol refuses all requests to talk about the Challenger incident. Asked to comment on Boisjoly's case, the company told *Spectrum* in a written statement, "It is our sincere belief that these articles serve no legitimate purpose, and continue to cause unwarranted suffering among our employees, the astronaut families, NASA, and the nation."

AVIATION, MARCH 1981:

A Federal Aviation Administration engineer appears on the television show "60 Minutes," charging that lives have been lost because of the agency's mishandling of collision avoidance system development.

Jim Pope had a clear vision of what he wanted to accomplish when he went to work as a mechanical engineer for the Federal Aviation Administration (FAA) in McLean, Va., in 1966. He had dealt with the agency through its district and regional offices in a five-year stint as chief of aviation safety in Nebraska's Department of Aeronautics in Lincoln in the early 1960s. Afterward, he experienced firsthand what he felt were inefficiencies in the agency's certification process when he started a company to sell a device he invented for preventing wheels-up landings.

"When I tried to get certification for my landing gear control, I found that the FAA officials didn't seem to care about the cash-flow problems that people on the outside were experiencing while waiting for certification," he told *Spectrum*. "I joined the FAA to get that agency moving in a positive direction of service to the aviation community."

But eventually, Pope's mission mushroomed when he concluded that the agency had lost any sense of its original purpose—making flying as safe as possible. The FAA's technical decisions, Pope believes, have needlessly cost the United States 1000 lives in airplane accidents since 1975.

In 1971, after heading R&D efforts at the FAA, Pope became

chief of the industry and government liaison division in the office of general aviation (nonairliner craft). "People in the small business aviation community across the country learned in a hurry that our office—and I in particular—was acting as ■ catalyst for getting them ■ timely response," he said. "We got ■ lot of attention, and we got ■ lot of things done."

Over the next two years, Pope circulated in meetings among the top leaders of the agency, and began questioning the agency's decisions to spend millions of dollars for R&D on two systems that he felt were unnecessary.

One was a collision avoidance system that would prevent midair crashes through ground radar. In 1972, after two years of work on a system that the agency believed would be on-line in 20 years, the FAA was approached by Honeywell Inc., Minneapolis, Minn., with an airborne collision avoidance system (ACAS), which allowed planes to communicate directly without the ground as go-between. An onboard box would create an egg-shaped envelope of RF energy around each craft, and when two envelopes overlapped, the system would warn the pilots of ■ potential collision 45 seconds beforehand. If no action was taken 25 seconds from ■ crash, the system would give complementary commands for evasive action to both pilots.

Congress directed the FAA to evaluate the Honeywell ACAS, as well as two others by RCA Corp. and McDonnell-Douglas Corp. in a four-year, US $12 million program. The conclusion of the study, according to Pope, was that the Honeywell system was the best and the least expensive at US $1000 for small aircraft and US $7000 for airliners, and as stated by an FAA executive committee report of Dec. 16, 1975, that it "meets all the objectives of the agency."

But the FAA told Congress that ACAS caused too many false alarms and that it was concerned about the system's compatibility with the current air-traffic control system. Pope charges that the FAA lied to keep its own development program alive.

"ACAS conflicted with their NIH [not-invented-here] mindset," said Pope. "They wanted control of every airplane from the ground, so they weren't going to certify it."

With the backing of his boss, Pope wrote what he called "hard-hitting" letters to FAA administrator John L. McLucas, trying to convince him of the merits of selecting Honeywell's ACAS. In response to these letters, Pope said, and a run-in with the agency over its microwave landing system (MLS), another technology he said was already available from industry, the next FAA administrator, Langhorne Bond, eliminated the office of general aviation in 1978, fired Pope's boss, who supported Pope's positions, and transferred Pope to the FAA's Seattle office.

The FAA pursued the development of a ground-based system called the discrete address beacon system (DABS), in which air-traffic control would send warnings and evasive action when necessary. The agency also worked on an interim technology it told Congress would be ready in 1978, called the beacon collision avoidance system (BCAS). The active version of BCAS, in which aircraft would have their own receivers so they could interrogate transponders on other aircraft directly, is the basis for the agency's current TCAS (traffic alert and collision avoidance system). Unlike ACAS, BCAS would not allow the two closing craft to communicate and so each would have to take independent evasive action.

Jim Pickerell

Former Federal Aviation Administration (FAA) aerospace engineer Jim Pope (at right) is writing ■ book about his experiences at the FAA.

Pope claims that ■ 1975 study on midair collisions conducted by Mitre Corp. found BCAS to be dangerous, creating interference problems in high-density areas. In a study the next year, Mitre examined the 494 midair collisions that occurred in a prior nine-year period and concluded that improvements in the air-traffic control system could have prevented 118 of them; BCAS would have prevented 120; DABS would have avoided 190; and ACAS came out on top, preventing 228. Nonetheless, problems with DABS moved FAA administrator J. Lynn Helms in 1981 to make the BCAS technology the focus of collision avoidance efforts, though Helms renamed it TCAS, Pope charges, to make it appear to be a new technology. TCAS, which airlines began installing this year, costs about US $150 000 per aircraft.

When Pope was sent to Seattle in 1979, his family remained in McLean, Va., where he had just built ■ house. After arriving, he found he had little to do, and his boss eventually told him that the job had been fabricated to get him out of FAA headquarters. After a long and fruitless struggle to get reassigned to FAA headquarters, in 1981, Pope went public with his story, appearing on "60 Minutes" and testifying before Congress' Subcommittee on Transportation, Aviation, and Materials.

Pope said the FAA then began ■ campaign of harassment to build a case for terminating his job. His management reprimanded him for insubordination, failure to carry out orders, and improper use of duty time. When Pope began experiencing stress-related symptoms, including three kidney stone attacks, his doctors recommended that he take sick leave and return to his family in Virginia. A few months later, the agency fired him.

Pope contested his firing as a violation of laws prohibiting retaliation against Federal employees who testify before Congress. In order to prevent ■ public hearing, Pope believes, the agency converted his termination to retirement due to disability.

FAA associate administrator for regulation and certification Anthony J. Broderick commented on Pope's charges in a written statement to *Spectrum*: "In ■ perfect world, the [TCAS and MLS] projects may have moved faster and in a direct line from conception to production. But aviation research and development is not filled with black and white choices.... Mr. Pope would have your reader believe that the development of the collision avoidance system was victimized by small-minded bureaucrats, and as a result a needed safety innovation was unconsciousably (sic) delayed. To say this, is to be less than accurate...."

In 1985, Pope found employment at NASA's Goddard Space Flight Center in Green Belt, Md., working as an engineer on the Cosmic Background Explorer (COBE) and later the space station. But he left NASA in 1988 after a heart attack. He is now writing a book documenting his experiences at the FAA.

To probe further

A good overview of whistle-blowers in a variety of professions (including discussion of the Boisjoly and Pope cases) is *The Whistleblowers: Exposing Corruption in Government and Industry* by Myron Peretz Glazer and Penina Migdal Glazer, Basic Books Inc., 1989.

For information on the remedies available to government and corporate whistle-blowers, contact Sarah Levitt, intake coordinator at the Government Accountability Project, 25 E Street, N.W., Suite 700, Washington, D.C. 20001; 202-347-0460. ◆

Software workstations: one-stop shopping for utilities

Packages integrating functionally related software developed throughout the power industry simplify tasks ranging from transmission line design to equipment troubleshooting

To help electric utilities use their software more efficiently, California's Electric Power Research Institute (EPRI) has been integrating groups of programs related to common engineering functions—for example, system grounding—into single packages. More than a dozen of these packages are already available. Almost a dozen more, in various stages of development in the Palo Alto institute's technical divisions, are scheduled to be ready between now and 1993 [Table 1]. What they offer is one-stop shopping for software solutions.

Whether a project involves designing a new transmission line, troubleshooting an equipment problem at a power plant, or planning for future generating needs, utilities have for many years used software to get the job done fast while keeping expenses down. More recent advances in computing power and software engineering have even accelerated the development of programs for utility applications.

The original programs, though, evolved one at a time over the years. They rely on a wide variety of databases and interfaces, so users have had to develop input data for each program, and little of their experience in learning how to run it carries over to learning another. In addition, some of the older programs were written for large mainframe computers, which are less user-friendly and less accessible than the personal computers and engineering workstations now in widespread use.

To circumvent these difficulties, EPRI has packaged sets of anywhere from two to more than a dozen functionally related but heretofore separately available programs. These packages it calls "workstations," and each of them allows a number of interdependent tasks to be performed much more efficiently than before.

"The areas these 'workstations' cover have been identified by various technical projects and their advisory task forces as key areas of engineering expertise," pointed out Narain Hingorani, vice president of EPRI's Electrical Systems Division. The software is available at no charge to utilities belonging to EPRI, and for a fee to foreign and all other companies.

To develop the "workstations," EPRI's programmers first translated the programs for mainframes into versions for personal computers and engineering design computers. The programs' input and output structures were then modified so they could function in a shared framework, and a common database was designed for them.

Summarized in Table 2 are the computer hardware, operating systems, and user interfaces employed in the "workstations." Most of them operate on 386- and 486-based IBM Personal Computers or compatibles. Some run on engineering design computers manufactured by Sun Microsystems Inc. (Sun workstations), Digital Equipment Corp. (MicroVAX), or IBM Corp. (RS6000).

Most of the EPRI "workstations" rely on the DOS operating system, while some utilize OS/2 or Unix. As for the user interfaces, EPRI has tried to make them as friendly as possible by exploiting graphical user interfaces already on the market, in addition to developing a graphical interface of its own.

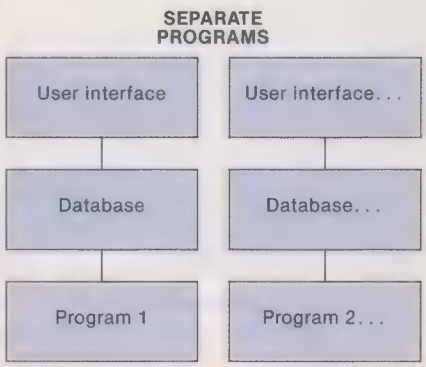
Transmission line 'workstation'

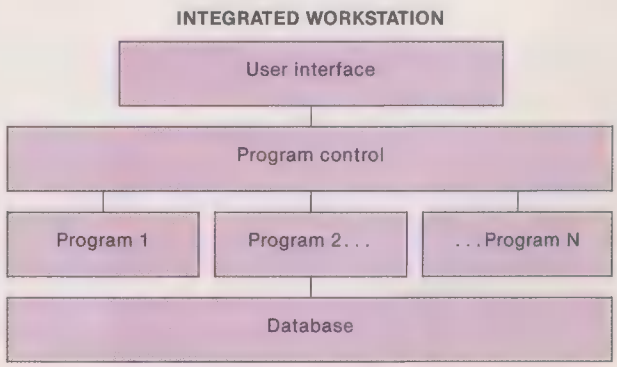
Perhaps the best known of the "workstations" already made available and in service is the Transmission Line Workstation developed and managed by EPRI's Overhead Transmission Program. It integrates 16 programs covering virtually every aspect of transmission line design—from analyzing the strength of concrete piers to computing sag and tension in overhead conductors [Table 3a].

All the programs within TLWorkstation, as is the case with the other "workstations," share input data and all operate the same way so far as the user can tell. Moreover, they are consistent in look and feel, so that learning a new program takes much less effort than before [see diagram below].

Steve Hoffman Technical Writer
Giora Ben-Yaacov Electric Power Research Institute

Using different computer programs can mean learning an interface and developing a database for each. EPRI's software workstations integrate two or more programs under a single interface and common database, simplifying the user's job.





0018-9235/90/1200-0053$1.00©1990 IEEE

Another key area ripe for a "workstation" is system grounding. For years, utilities have used software to analyze and design grounding systems for substations, transmission structures, and distribution equipment. But these programs have never operated under a common user interface or used a common database. EPRI's System Grounding Workstation does both.

The SGWorkstation integrates substation- and transmission-grounding programs, streamlining data preparation, data updating, and operation. A utility engineer can use one of the substation-grounding modules to spot unacceptable touch voltages, then switch to another module to analyze the electric current distribution among grounded structures for various fault conditions [see top photo, p. 55].

With the information from these programs, the engineer can determine which parts of the substation ground grid must be modified to satisfy safety requirements. Then he or she can switch to one of the transmission-grounding modules to calculate the performance of the grounding system for the transmission line structures. EPRI plans to incorporate more software into the SGWorkstation, including distribution-grounding programs, in 1991 and 1992.

For any application

The beauty of the software workstation concept is that it can be applied to any group of engineering functions. A "workstation" can be developed for functions that are closely related or it can link programs that address different aspects of a larger area of analysis. The latter combination enables users to develop more efficient and comprehensive approaches to problem solving.

For example, the Resource Planning (RP) Workstation, one of several being developed in EPRI's Power Systems Planning and Operations (PSPO) Program, will combine supply-side, transmission, and demand-side planning in one package with risk analysis. Each of these types of analysis addresses different aspects of the resource-planning problem; integrating them can help utilities evolve coordinated strategies for meeting future needs. This effort is coordinated with EPRI's Customer Systems Division and the Utility Planning Methods Center.

"The difficulty in developing the RP Workstation is that the fairly complex computer programs involved were developed by different vendors for different EPRI technical divisions. Integrating them is not easy, but the potential rewards are great," noted Neal Balu, manager of the PSPO Program.

Another "workstation" with potentially great rewards for users is the EMTP Version 2.0 PC Workstation. Before this package was developed, EMTP—the Electromagnetic Transients Program—was a large, batch-oriented mainframe computer program for simulating high-speed transients in power systems. Capable of modeling momentary voltage surges lasting fractions of a second to several seconds, EMTP can be applied to switching surge analysis, synchronization problems, insulation coordination, and other important applications that make it possible for engineers to design cost-effective countermeasures to transients.

Although a powerful program, the mainframe version of EMTP lacks the user benefits of PC-based software—interactive operation, menu screens, and ease of use. EPRI's EMTP Workstation puts the program into the PC framework.

Input data preparation, calculations, auxiliary routines, and output processor modules are integrated by the Presentation Manager graphic interface under the OS/2 operating system [see bottom photo, p. 55]. Users can easily and consistently view and manipulate data, open two or more screen windows simultaneously, and use a mouse to change the location and size of the windows—much as they would rearrange sheets of paper on a desk.

In the area of stability analysis, several programs examined the individual phenomena separately. For example, EPRI's Small Signal Stability Program performs small-signal analysis, and the Extended Transient-Midterm Stability Package performs stability analysis in the midterm range. However, the phenomena examined separately in these programs are related; examining them by means of an integrated software package could suggest more comprehensive solutions or strategies.

With this need in mind, EPRI's PSPO Program is developing a Stability Analysis Workstation that will enable users to select from a battery of programs that address the full range of stability analysis issues [Table 3b]. Pulling all these tools together should dramatically streamline stability analysis for utilities.

1. Electric Power Research Institute 'workstations'

Name	Available	Computer system
Transmission Line Workstation (TLWorkstation)	Now	PC
Distribution System Workstation (DS Workstation)	Now	PC
T&D Systems Grounding Workstation (SGWorkstation)	Now	PC
Electromagnetic Transients Workstation (EMTP Workstation)	Now	PC
Resource Planning Workstation (RP Workstation)	Now	PC
Relay Coordination Workstation (RL Workstation)	Now	PC
Plant Monitoring Workstation (PMW)	Now	DEC VAX-VMS
Stability Analysis Workstation	Now	IBM, VAX, & Prime mainframes
Boiler Maintenance Workstation (BMW)	Now	PC
Cooling Tower Advisor (Coolta)	Now	PC
Reliability Analysis Program with In-Plant Data Workstation (Rapid Workstation)	Now	PC
Fly Ash and Scrubber Sludge Transport and Chemistry (Fastchem)	Now	PC, IBM mainframes
Fuel Planning Workstation	Now	PC
Load Data Analysis Workstation (LDAW)	Now	PC
End Use Market Assessment Workstation	1993	PC
Machine Insulation Condition Assessment Advisor (Micaa)	1991	PC
Retaining Ring Life Assessment Workstation	1991	PC
Substation Insulation Coordination Workstation	1991	PC
Protective Relay Evaluation Workstation	1991	PC
Electric and Magnetic Fields Workstation (EMF Workstation)	1992	PC
Underground Transmission Workstation	1993	PC
Lightning Protection Design Workstation	1993	PC
Distribution Power Quality Workstation	1993	PC
Value-Based Transmission Resource Analysis Workstation (VBTRA Workstation)	1993	PC
Substation Design Workstation	1993	PC
Operator Training Simulator	1993	Sun

Nuclear plant 'workstation'

One of the most comprehensive "workstations" available is one developed by EPRI's Nuclear Power Division and called the Reliability Analysis Program with In-Plant Data (Rapid) Workstation. Its scope is the entire nuclear power plant. Rapid models a variety of on-line and off-line applications, including plant monitoring, performance evaluations, and reliability analysis. The package contains so much that it can be considered the ultimate integration of software for one type of power plant.

For on-line applications, a plant status monitoring (PSM) module keeps track of plant equipment status, equipment operability, and procedural compliance. Utilities can use PSM to evaluate plant health, availa-

bility, and reliability. In addition, the module produces equipment maintenance tags, compiles equipment failure and repair histories and maintenance records, and prepares event records and shift logs.

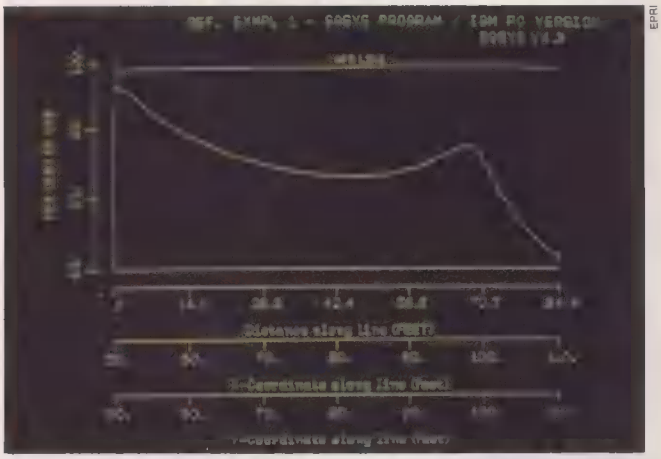
A utility module provides off-line analyses of on-line data, such as performance evaluations, analyses of operational impacts on component aging, and maintenance priorities. Another off-line module, the reliability assessment module (RAM), helps utility engineers perform an array of system reliability and availability analyses.

A key application of this module is performing probabilistic risk assessments or individual plant evaluations required by the Nuclear Regulatory Commission. As part of an ongoing risk management program, RAM can provide up-to-date quality assurance and quality control documentation. To render this huge package less formidable, Rapid includes a menu-driven executive interface and ■ sophisticated database manager. Prerelease testing of the software has been completed to rave reviews, and Rapid is now available.

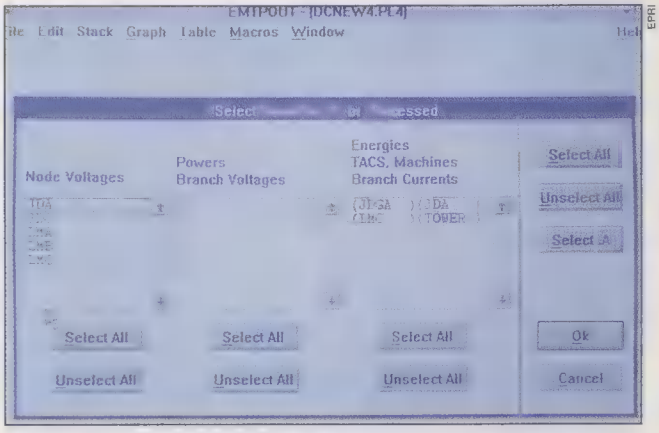
Diverse needs, different 'workstations'

"At Arizona Public Service, we've found new ways of organizing tasks in some areas to improve productivity," said Hanna Abdallah, a senior engineer in transmission substation engineering. "We were surprised to find that several of EPRI's 'workstations' are organized according to our way of doing things."

Recognizing that utilities vary in their approach to organizing tasks, EPRI has tailored its "workstations" to diverse needs.



Output graphics in EPRI's System Grounding Workstation, or SGWorkstation, shows the ground potential rise in the substation following a short circuit on the transmission line.



Selection menu based on Presentation Manager graphical user interface streamlines the program selection process in the Electromagnetic Transients Workstation, or EMTP Workstation.

2. Computer environment for EPRI 'workstations'

Computer hardware	Most on PCs (386 and 486-based systems), some on engineering design computers (Sun, MicroVAX, IBM-RS6000)
Operating system	Most on DOS, some on OS/2 or Unix
User interface (look and feel)	Within a given workstation, a common look and feel is maintained; Windows, Presentation Manager, X-Manager, X-Windows, or EPRI-developed interface are all used
Computation language	ANSI Fortran or ANSI C
Database software	Relational database management software with SQL interface is used; EPRI database access integration services (DAIS) will be used to interface to external databases
Knowledge base and tutorials	EPRIgems procedures for implementing expert system methods are used in some workstations to streamline the decision analysis process

For example, in response to public concern over the possible risks to human health posed by exposure to power-frequency electric and magnetic fields (EMF), software has been and is being developed to help utilities address EMF issues.

At some utilities, specialists need to assess human exposure to electric and magnetic fields associated with substation, transmission, and distribution networks. Combining software developed by its Environment and Electrical Systems Divisions, EPRI has begun development of an EMF Workstation that will aid in these assessments.

At other utilities, the study of work issues is decentralized: transmission designers may address work issues that pertain only to transmission lines. For this reason, EPRI has included relevant EMF software in the TLWorkstation mentioned previously. Using a program called Enviro, transmission line designers can calculate electric and magnetic fields around high-voltage transmission lines and then switch smoothly to one of 15 other TLWorkstation modules to work on such things as transmission foundation analysis and design, structural analysis and design, or line analysis and optimization.

The TLWorkstation exemplifies ■ key feature of EPRI "workstations"—a common database. A project input module accepts input data that are common to two or more task modules. The data may be common to an entire transmission line, a line segment, or lines built with a common structure. Because each of the other task modules can access the common database, the user has to input data only once, except when updating is required.

"Before we started using the TLWorkstation, we had to build several separate databases for our transmission software," noted Casimir Gudin, ■ transmission engineer with Centerior Service Co. "Now, by building and updating one master database, we save ■ lot of time."

Generating unit 'workstations'

Several workstation packages are being developed for troubleshooting plant operations and improving plant performance. These functions can be performed on-line to evaluate current plant operating conditions and provide guidance on performance, equipment degradation, and maintenance needs. Off-line analyses, based on the use of archived data, supply similar results.

A collaborative effort of EPRI's Generation and Storage Division and Electrical Systems Division, the Plant Monitoring Workstation (PMW) focuses on on-line analysis. The "workstation" interfaces with the plant computer and other instrumentation to obtain current operating data, which are also archived for trending and other off-line analyses. The benefits of using these data include improving plant heat rate, which is ■ measure of how well the plant converts fuel into electricity, enhancing maintenance planning, and increasing availability of equipment.

According to project manager Dominic Maratukulam, "determination of on-line heat rate over the load range enables more efficient unit dispatch."

The PMW's software was designed with a modular approach that facilitates long-term maintainability, standardization, self-documentation, flexibility of configuration, and consistency of calculations. This building-block design makes the system adaptable to changed applications over time. Moreover, it allows the "workstation" to interface with plant computer systems already in place. For example, the PMW uses the plant's data acquisition and operator control stations to display results with text and graphics that are familiar to the operating personnel.

Boiler maintenance

A program package that performs off-line analysis is the Boiler Maintenance Workstation [Table 3c]. This "workstation" helps utility engineers and maintenance personnel diagnose and prevent boiler tube failures. To this end, it contains modules for tracking tube failures, analyzing ultrasonic tube-wall-thickness data, determining optimum inspection intervals, and predicting the remaining lifetime of the boiler's water-wall, superheater, and reheater tubes. The package even includes an expert system for determining tube failure mechanisms and guiding a root cause analysis.

The Boiler Maintenance Workstation is easy to use even by those with little or no computer experience, thanks to a user interface developed by the institute's EPRIgems project. "EPRIgems is a product line of computer codes in which all software looks and feels the same," explained project manager David Cain. "It makes selected software more user-friendly and accessible to utility users." The "workstation" uses simple pull-down and pop-up menus, fill-in-the-blank forms, graphics, and spreadsheets.

While EPRI's involvement in software development includes program definition, R&D, testing by utilities, and distribution by the Electric Power Software Center (EPSC), it also emphasizes user support. Said EPRI's Hingorani, "We're committed to evolving interactive means to ensure that utilities get the most out of EPRI software."

Centralized software services—performed by Power Computing Co. of Dallas—consist of distribution through the EPSC, support, and a user hotline. In addition, there are individual "workstation" support centers. Each is really a network that encompasses the EPSC, R&D contractors, a users' group, and EPRI staff, which together can provide a host of services—including hotlines, software maintenance, training, newsletters, and utility-specific enhancements.

3 Programs included in sample workstations

a. Transmission Line Workstation (TLWorkstation)	
PIM	Project Input Module
Etads	EPRI Tower Analysis and Design System
Wirelds	Guy Wire Loads
Minides	Mini-Design Program
Framer	H-Frame Tower Reliability
Poldar	Power Pole Design, Analysis, and Reliability
MFAD	Moment Foundation Analysis and Design
TLOPWT	Transmission Line Design Optimization with Terrain
SAGT	SAG-Tension Analysis
Multif	Lightning Flashovers of Transmission Lines
Corridor	Right-of-Way Sharing with Railroad and Pipelines
Cufad	Compression/Uplift Foundation Analysis and Design
Dynamp	Dynamic Ampacity (line capacity)
GATL	Grounding Analysis for Transmission Lines
Enviro	Corona Effects and Electric Field Profiles
RNOISE	Radio Noise
b. Stability Analysis Workstation	
ETMSP	Extended Transient-Midterm Stability Program
SSSP	Small Signal Stability Program
Direct	Direct Stability Analysis Program
Loadsyn	Load Models for Stability Program
Dyneq	Dynamic Equivalent Program
c. Boiler Maintenance Workstations(BMW)	
Tube records database	
Water-wall tube condition module	
Escarta expert system	
Tubelife life-prediction code	

Future directions

While EPRI "workstations" have already benefited utilities in many ways, the future EPRI packages may be even more powerful and intelligent. Incorporating artificial intelligence or expert systems technology into the interface of an existing EPRI "workstation" can help users solve complex problems faster and without too much of a struggle.

In fact, an expert system has already been added to the Boiler Maintenance Workstation. Called Escarta, the system queries the user about the circumstances of a tube failure and provides an analysis of the failure mechanism. Once the failure mechanism is known, the system lists potential root causes, along with recommendations for verifying the cause, repair and inspection procedures, and guidelines for preventing future failures. This type of embedded intelligence can be applied to many other "workstations."

The software workstations of the future may also have more horsepower. For example, the implementation of EPRI "workstations" on hardware that uses the Unix operating system could put the power of a 1980s-vintage mainframe computer on the desktops of utility engineers in the 1990s. Such high-powered, enhanced "workstations" could open up new opportunities for desktop design and analysis without sacrificing ease of use. EPRI and members of the utility community are discussing these possibilities.

To probe further

Simulating high-speed transients in power systems with the electromagnetic transients program is discussed in "EMTP: Designing for Disaster," *EPRI Journal*, Vol. 14, No. 7 (October/November 1989), pp. 32–35.

More information on overhead transmission line design and analysis is covered in "TLWorkstation: Expert Assistance in Line Design," *EPRI Journal*, Vol. 14, No. 5 (July/August 1989), pp. 32–39.

For a discussion of expert systems applied to electric utilities, see "Delivering On-Line Expertise," *EPRI Journal*, Vol. 14, No. 3 (April/May 1989), pp. 24–33.

For more information on EPRI workstations, contact author Giora Ben-Yaacov, EPRI, Box 10412, Palo Alto, Calif. 94303; 415-855-2879.

About the authors

Steve Hoffman of Santa Clara, Calif., is a freelance technical writer and consultant in the energy and environment field. He has written extensively for the Electric Power Research Institute, in Palo Alto, Calif., electric utilities, and consulting firms for seven years. He holds a master's degree in mechanical engineering from Stanford University.

Giora Ben-Yaacov (SM) has managed software R&D projects for EPRI's Electrical Systems Division since 1981. Previously a senior consultant at Systems Control Inc., he holds a Ph.D. in power systems engineering from the University of Cape Town, South Africa, and a master's in nuclear engineering from the Technion, Israel Institute of Technology in Haifa.

A version of this article was originally published in the July/August 1990 issue of the *EPRI Journal*. ◆

Siemens: making marketing as important as technology

Germany's engineering giant is investing billions of Deutsche Marks in a restructuring and acquisition program to enhance its international competitiveness

The mood at Siemens AG, the biggest electronics company in Europe, is upbeat. In the last few years, the Munich-based corporation has shelled out billions of Deutsche Marks (DMs) in an aggressive policy of expansion by acquisition both at home and abroad. Last year, it instituted a sweeping restructuring, spelling out substantial changes for most of the company's businesses. Most impressively, it has managed to juggle these potentially disruptive changes while sticking (more or less) to its policy of no layoffs for its 350 000 employees and maintaining a respectable financial performance.

For years, competitors have claimed that Siemens's survival depended on a domestic market guaranteed by large Government contracts. The financial community has criticized it for a perceived overemphasis on making technologically perfect products at the expense of profits. Its generous employee benefits package and its aversion to laying off employees have been called outdated and paternalistic.

"We've had some problems," Andreas Zimmermann, vice president for corporate planning and development, told *IEEE Spectrum*, "but we've decided that being market-driven is our first priority. We want to shift marketing to the same level of importance as technology."

To better manage its businesses on a worldwide basis, the company has split up seven large divisions into 15 smaller ones, giving each worldwide responsibility for a particular technology—such as computers, private telecommunications, and power generation. It has reduced its board of directors from 28 to 10 and relieved it of any day-to-day role in running these businesses, a measure designed to make the board more objective and faster-acting in making business decisions.

Necessity to globalize

Over the past 10 years, the skyrocketing cost of research and development has made it essential for large firms to globalize—establish large volumes of business in marketplaces around the world—to generate a sufficient payback from increasingly large investments. Earlier in the 1980s, IBM Corp., General Electric Corp., Fairfield, Conn., and other U.S. and British companies made similar moves to streamline management. In 1987, NV Philips, Eindhoven, the Dutch electronics firm that is second only to Siemens in Europe, instituted strikingly similar reforms in management structure. But as William T. Coleman, an analyst at James Capel & Co. in London, said, "Siemens is conservative. They've done everything on their own until the last two or three years."

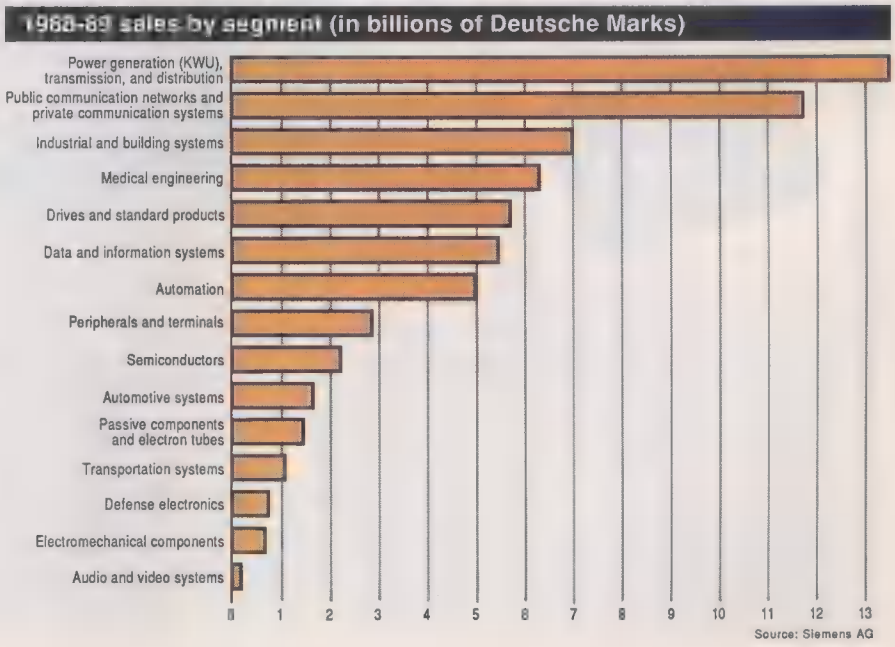
Siemens is, first and foremost, an engineering company. Its current chairman, Karlheinz Kaske, is an electrical engineer, as was his predecessor. If a company can be said to possess a soul, Siemens's could only be that of Werner Siemens, the mustached Hanoverian engineer and inventor who founded Telegraphen-Bau-Anstalt von Siemens & Halske in 1847 in Berlin to market the pointer telegraph, his first invention.

The machine had a dial and keyboard that allowed operators to send messages without having to tap out Morse code. Soon his company branched out to other innovations—the electric dynamo, the locomotive, and the telephone. Except for a brief attempt at manufacturing automobiles in the early 1900s, Siemens has stayed with what it knows best—electrical engineering.

'Siemens town'

Werner Siemens's original approach was not very different from the company's current one. Having read about and admired the Fuggers, a rich and influential merchant family in southern Germany in the early 16th century, he set out to establish his own prosperous family business. He succeeded in winning the respect of Germany's rulers and in playing a vital role in the development of German industrial society in the late 19th century.

Indeed, the impact of Siemens and his heirs on German soci-



Fred Guterl Correspondent

0018-9235/90/1200-0057$1.00©1990 IEEE

ety is perhaps as great as on technology and industry. Siemens & Halske was one of the world's first big companies to establish a pension fund, profit-linked bonuses, and insurance aimed specifically at its white-collar staff. The firm's headquarters in Berlin was named Siemensstadt—or "Siemens town"—in 1913 to reflect its tremendous size, which by 1920 had reached 30 000 engineers, factory workers, and other staff .

Siemens & Halske did not get that big by selling widgets but by winning Government contracts. After the invention of the dynamo, the growing firm supplied burgeoning Germany with electric power generated by coal, oil, and eventually nuclear power. It also provided railroads for transport and mining, electric lighting, telegraphy and telephony. Almost from the beginning, Siemens acquired a taste for so-called big systems-projects that require diverse technical and management expertise as well as the ability to raise huge amounts of capital for research, development, and construction.

Big industrial companies such as Siemens have always enjoyed close relationships with big German banks, such as the giant Deutsche Bank, that issue their shares, lend them money, provide advice, and participate in management via a seat on the board of supervisors, an arrangement similar to some in Japan. The structure of ownership gives the Siemens family 25 percent of the vote at shareholders' meetings, out of proportion to their actual holding of company shares.

These factors help explain the conservative nature of German industry, whose managers are said to suffer less from pressures for short-term results than do their counterparts in the United States. Indeed, Siemens keeps more than US $12 billion in cash on hand for a rainy day, and admits to understating its earnings to avoid paying German taxes.

This relatively protected environment has played a part in Siemens's evolution as a "service-oriented company," as executives describe it. Rather than specializing in narrow industries, as U.S. companies tend to do, or concentrating on manufacturing, like Japanese companies, Siemens has opted for a broad mix of businesses that generally involve as much consultation, maintenance, and expertise as possible. Executive director Eberhard Posner told *IEEE Spectrum*, "If BMW builds a new factory, Siemens takes a leadership role. So we need to have people who can implement the whole factory structure. We're a kind of industrial customs house."

Siemens's major goal—a leadership role in all of the major world markets—is not new. By the early 1900s, when German industry expanded spectacularly, Werner Siemens and his brothers had made it their business to develop the technological infrastructure not only of the Kaiser's Reich but also of Queen Victoria's Empire and the Tsar's Russia. Siemens installed a telegraph line in Russia from St. Petersburg to the Crimea in 1855, from London to Calcutta, India, in 1868, and from Ireland to New York in 1874.

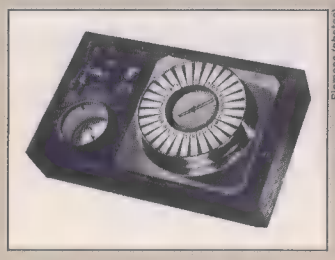
Between then and now, Siemens lost all of its overseas assets in the world wars, including patents, factories, and equipment. For years afterward, it was barred by the Allies from such industries as nuclear power and computers. Gradually, Siemens bought back its overseas assets and won greater freedom. However, only in the late 1970s and early 1980s, when West Germany and its West European neighbors began to seriously consider forming a single European market, were the Deutsche Bundespost, which operated the country's telephone network, and other Government purchasers forced to wean Siemens from preferential treatment.

Removed from shelter

By the mid-1980s, the European Commission in Brussels began to issue directives aimed at introducing more competition into procurement and services. (These decrees the member states are bound to comply with under the laws of the Economic Community.) For instance, the Bundespost was compelled to separate its regulatory from its operating and procurement functions on July 1, 1989. Sooner or later, deregulation and the unification of Europe's markets in 1992 are bound to encroach on other protected industries, such as power generation and transportation, that make up the Siemens portfolio.

Siemens's telecommunications business illustrates the economic and technological considerations. So far, sales of public and private switches have grown briskly, and analysts believe that these two divisions—which together brought in 24 percent of Siemens's DM 61.1 billion (US $40.3 billion) sales revenue in 1988–89—are the company's most profitable.

Siemens does not disclose profits for individual businesses. But



Siemens (photos)

The cable-laying ship Faraday, *built to the Siemens brothers' design.*

Siemens's 1878, 1884 telephones.

1847: Werner Siemens and Johann Georg Halske found Siemens & Halske Telegraph Construction Company in Berlin.

1851: Siemens & Halske wins Council Medal for the pointer telegraph at the World Exhibition in London.

1855: The Russian branch of Siemens & Halske is established in St. Petersburg by Karl Siemens.

1858: The English branch of Siemens & Halske is established in London by William Siemens (renamed Siemens Bros. in 1965, after the company built the Woolwich cable works).

1866: Werner Siemens discovers the dynamo-electric principle and builds the first dynamo.

1870: The Indo-European telegraph line is constructed. Spanning 11 000 kilometers, it connects London, Berlin, and Teheran and Bushire in Iran, to Karachi in Pakistan and Calcutta in India.

1874: The Faraday, a specially built ship for laying cable, links Ireland and New York City.

1879: The first electric railway carries 90 000 visitors at the Berlin Trade Fair.

1880: The first electric elevator is demonstrated at the Mannheim Pfalzgau exhibition.

1881: The first electric tramway is demonstrated near Berlin.

1885: Berlin inaugurates its first major power station at Markgrafenstrasse.

1890: Siemens & Halske becomes a limited partnership.

1892: Four years after being raised to the nobility as Werner von Siemens, the founder dies.

1896: The Budapest underground railway opens.

1897: Siemens & Halske becomes a joint stock company.

1900: The first automatic telephone exchange in a major European city

it is known that roughly 40 percent of its revenue comes from Bundespost orders, whose prices per telephone line are seven to eight times more than in the United States, according to industry analysts. [Siemens executives say the ratio is much lower, but decline to be specific.] Competition has indeed been slow in coming, despite reform in the Bundespost; in the last two years, Siemens won both of two major telephone switching system orders.

Even so, the firm's strategic planners expect public telecommunications to feel the pinch of rising R&D costs and greater competition. Development expenses for the next generation of the EWSD, the company's main public switching project, are expected to run to DM 2 billion. "We need larger markets to get a return on our R&D investment," said Karl J. Frensch, director of public telecommunications marketing at Siemens. "These large systems need such a large amount of R&D that our domestic market is too small."

Siemens AG

Sensors and artificial intelligence equip this mobile "aware" machine from Siemens to navigate its way autonomously through a changing environment.

Orgy of acquisitions

With the acquisition of GPT Telecommunications, a switch manufacturer in Coventry, England, Siemens won entree into Europe's most competitive telecommunications market. But EWSD has not fared particularly well in the United States, where the most technically advanced products are demanded.

In 1988, Siemens bought Rolm Corp., Santa Clara, Calif., a maker of private-branch exchanges (PBXs), from IBM. Last year, Siemens and General Electric Co. of London succeeded in a hostile takeover of GEC Plessy Telecommunications, the British electronics firm that owned GPT, carving up chunks of the company and dividing the spoils between them. Then in November Siemens announced a merger of its U.S. business with Stromberg-Carlson Corp., a unit of GPT, creating the third-largest North American supplier of telecommunications equipment, behind AT&T and Northern Telcom.

Siemens has been more needy of acquisitions in the computer industry. This year it acquired INZ SA, Paris, France, a personal computer firm, and Nixdorf Computer AG, Paderborn, Germany, which sells Unix minicomputers and workstations. Before buying Nixdorf—easily its most spectacular acquisition so far—Siemens was just one of many struggling computer-weaklings in Europe. With Nixdorf, it leaped to second place on the continent behind IBM, with combined revenues in 1989–90 of DM 13 billion and growth this year expected to reach 20 percent.

Siemens had been looking for an acquisition or a partnership to bolster its European market position. It held talks with International Computers Ltd. (ICL), London, the firm that has since been acquired by Fujitsu Ltd., Tokyo, but rejected ICL as a bad fit with its businesses. The deal between Nixdorf and Siemens was made between Christmas 1989 and New Year's Day—a speedy time frame that, Siemens executives say, epitomizes the new streamlined Siemens. Outsiders, including such would-be buyers as Italy's Ing. C. Olivetti & C. SpA, and France's Compagnie des Machines Bull, noted that Nixdorf had not approached other potential buyers, and the sale meant that German assets remained German-owned.

To give the new operations independence, Siemens decided to create a separate subsidiary. The first task will be to stem Nixdorf's losses and mediate differences between Paderborn and Munich. To reduce staff, Siemens already has offered incentives for voluntary retirement in its computer division.

8000 nonbusy nuclear engineers

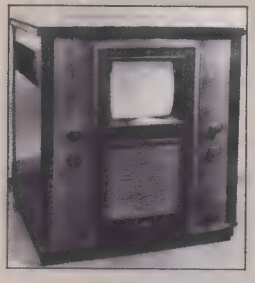
Nuclear power is another problem area. With no growth predicted in that business for the next five years, Siemens's Power Generation Group (KWU) last year found itself with 8000 nuclear engineers who were not very busy. "That's part of our problem," Hans-Joachim Preuss, senior director of marketing, told us. "We're a big engineering company and we're overstaffed."

Although new orders fell to a trickle in the late 1970s and then dried up, KWU has managed to stay profitable through the 1980s by completing its previous contracts, which typically last 10 or more years. This year, sales stagnated at DM 6 billion.

Attention to new markets has led to an agreement with the power company Framatone et Cie, Paris, for a joint venture in pressurized-water reactors. Bechtel Group Inc., San Francisco, the construction firm, has agreed to market Siemens's expertise in servicing nuclear power plants in the United States. And three years ago, Siemens acquired Advanced Nuclear Fuels Corp.,

Ad for first tantalum lamps, 1905.

is installed, initially for 2500 subscribers, in Munich-Schwabing.



Telefunken 180-line TV set, 1939.

1924: A joint-interest association is set up with Westinghouse Electric Corp. in Pittsburgh.

1931–33: The first public telex service network is put into operation in the German Reich.

1939: Siemens readies the electron microscope, with a magnification of 30 000 times, for production.

1945: Allied forces seize Berlin and dismantle the Siemensstadt works.

1949: Siemens establishes headquarters in Munich.

1955: Allies lift the ban on research in the Federal Republic, allowing Siemens to resume research on nuclear power generation.

1966: Siemens AG is formed from the merger of Siemens holdings.

1989: The Berlin Wall is torn down; Siemens restructures its organization into 15 operating groups.

Bellevue, Wash., a manufacturer of uranium fuel rods. German reunification has opened up the prospect of work in what formerly was East Germany, repairing and replacing substandard plants, but no contracts have been signed.

Meanwhile, Siemens's nonnuclear power businesses are thriving. The biggest winner is its gas-steam turbine generator, which achieves an efficiency of 52 percent by reusing its own heat. Afterburners eliminate most of the nitrogen oxide exhaust, making the product popular with Germany's ecologically oriented Green Party. Three years ago, KWU sold three of the turbines; last year, it got 25 orders, including a big project in Killingholme, England, worth DM 1.5 billion.

Currently, half of Siemens's revenues are generated at home—an improvement over the past but still less than the stated goal of one-third domestic sales. The company's diverse businesses have a spotty distribution over the major world markets—in telecommunications and nuclear power, for instance—Siemens has virtually no presence in France. Particularly worrisome is the poor performance of Siemens Corp., the New York–based subsidiary, which lost US $341 million last year. Its biggest U.S. triumph has been in medical electronics—diagnostic imaging, cardiac pacemakers, and a miscellany of instruments and monitors. Success in the large and fiercely competitive U.S. market is essential to Siemens's long-term global strategy.

In semiconductors, the challenge is to keep its technology up-to-date without losing money. Whereas a specialized company like IBM can afford to manufacture dynamic RAMs and other chips only for internal use, Siemens requires a diverse assortment for its various businesses, and chips are too important to leave to outside suppliers. "With 400 000 people, we have to play for the long term," said Christoph Horstmann, director of semiconductor marketing. "We have to be a technology-driven supplier."

In the 1980s, Siemens not only lost money on chips but fell three to four years behind the curve in chip fabrication. To reverse the trend, R&D threw most of its muscle behind chip-making technology. In addition, Siemens sought help from Tokyo's Toshiba Corp., acquiring rights to its 1M-bit DRAM technology in 1984. In a parallel venture with NV Philips, the Mega project was begun in the same year to develop 4M-bit DRAMs and 1M-bit static RAMs (SRAMs). By 1989, when the Mega project ended, Horstmann reported that Siemens had brought its learning curve to within six months of the leading Japanese manufacturers, enough to begin to make a profit in an "up" market.

The effort to catch up culminated in 1989 in an agreement with IBM to develop 64M-bit DRAMs by mid-1995. The deal with IBM, one of the world's foremost chip-makers, was widely interpreted as a return to form.

Double sales or halve R&D

Siemens is expected to take the lead in European semiconductor sales this year. But even though semiconductor sales have grown by 50 percent (in number of units) in each of the last two years, costs are mounting so quickly—DM 560 million in R&D costs last year on only DM 2.3 billion in sales—that Siemens still needs either to double sales or to halve development costs. In response, it has entered into a spate of cooperative ventures—with SGS-Thomson, Paris, and Intel Corp., Santa Clara, Calif., on microprocessors and microcontrollers; with Toshiba on cell libraries and gate arrays; and in European government-sponsored ventures such as the Joint European Submicron Silicon Initiative (Jessi).

That other technology driver, R&D, suffered a setback when Karl Heinz Beckurts, the research director who masterminded Siemens's comeback in semiconductor research, was killed in 1986 by terrorists. But his successor, Hans Gunter Danielmeyer, has successfully moved toward a broader base of technology. In line with the overall restructuring, applied research—some 70 percent of which is software development—has been delegated to the 15 operating divisions, including the bulk of semiconductor work. That has allowed the central laboratories based in Munich, Erlangen, and Princeton, N.J., to focus on basic research in new materials and processes, components, software, and networks.

Leading the world on a broad technological front is a tall order. Whereas IBM has difficulty financing R&D in the basic technologies of computers, Siemens has the added burden of staying on top of it in nuclear and fossil-fuel power, telecommunications, and medical and automobile electronics—virtually every aspect of industry that involves electrons. The challenge is even greater considering the big-systems nature of its business. But in an era of rapid industrial consolidation, the giant that sprang from Werner Siemens's pointer telegraph believes that recent moves have positioned it as a contender for long-term success.

To probe further

Siemens's official history is covered in *The Siemens Company, Its Historical Role in the Progress of Electrical Engineering 1847-1980*, by Sigfrid von Weiher and Herbert Goetzeler, published by Siemens. Also, the Siemens Museum in Munich has on display original machines that exemplify the major inventions of the Siemens founders before World War II. Siemens is also the subject of frequent articles in the business and trade press in Europe and North America. ◆

Siemens's Augsburg plant

Squatting 6 millimeters square in a surface-mounted package with 320 pin-leads, the emitter-coupled logic LSI chip used in Siemens's 7500 H90 general-purpose mainframe looks like a tiny spider in a web. Sixteen are mounted in a shiny steel grid sandwiched between a heat sink and tiny printed-circuit boards. Each grid costs DM 35 000 (US $23 100). Nine grids are mounted on a water-cooled backplane and are, in turn, configured according to the computing capability required. Wolfgang Herberich, deputy director of Siemens's Augsburg computer plant, smiled proudly as he said, "Besides us, only IBM and two or three Japanese companies can do this."

Siemens's 7500 H90 general-purpose mainframe is too expensive and complex a machine, and its development time was too short, to allow for a lot of passing back and forth between development and manufacturing. So when Siemens three years ago built the plant, which uses just-in-time manufacturing techniques, executives first considered relocating its 500 development engineers from Munich to Augsburg, a one-hour drive away. In the past, development engineers worked for a different division of the company, but now they work directly for the factory. "None of them wanted to move," Herberich recalled, "so in the end we let them stay in Munich."

They are separated by distance only. Developers work in parallel with quality assurance and manufacturing engineers, so that the moment a new product is developed, the parts are secured and the equipment is waiting on the factory floor. "There is a very close connection the whole time between development and R&D," Gunter Leyendecker, a quality control specialist for original-equipment manufacturer (OEM) products at the Augsburg plant, told *Spectrum*.

While a new mainframe is being developed, Leyendecker evaluates the quality and availability of hard-disk drives from OEM suppliers and qualifies them for use in manufacturing. "The whole evaluation is done to find out if a blocking point will occur," he said. "We never have a case where a part is not available on time. It would be a complete failure of planning."

Leyendecker, a 36-year-old Ph.D. in physics, previously worked in Munich developing magnetic-disk storage devices for Siemens. He does not miss the technical work. "What I do now is a management job," he said, "but it's not too different from development, except you're working with different people. You need a technical overview, and that was my motivation for taking this job." —*F.G.*

Power engineering's powerhouse

From electrifying rural villages in India to helping to realize the Pacific Intertie, Narain Hingorani specializes in converting visions into reality

Medicine or engineering, which was it to be? Narain Hingorani, then finishing his second year at the Baroda University in India, pulled out a rupee and tossed the coin into the air.

Engineer, replied the coin that day in 1950, and Hingorani was launched on a career toward most of the prestigious recognitions available. Now vice president, electrical systems, of the Electric Power Research Institute (EPRI) in Palo Alto, Calif., he has been named to the National Academy of Engineering, made an IEEE Fellow, and awarded the IEEE Uno Lamm medal. "He is one of today's giants of electrical power engineering," Clifford C. Diemond, a former Bonneville Power Administration manager and now a consultant in Portland, Ore., told *IEEE Spectrum*.

Hingorani's success as an electrical engineer came as a great surprise—probably more to him than to anybody else. Born in what is now Pakistan, he had to emigrate to what is now India during the 1947 disturbances following the partition of India. As a child, he worked in his father's catering business; the family provided everything needed, from tents, chairs, and plants to food, and set it up overnight for weddings and parties. He was expected to try college and if that did not work out, there would be no shame in going into business, with the family or for himself.

Hingorani quickly evolved an unusual strategy for college—he would attend classes but pay little attention, and spend all his free time having fun until three months before exams. Then he would obtain exams from previous years, analyze them to determine key areas of study, and work very hard studying those areas. "I really studied only 50 percent of what I should have," he told *Spectrum*.

The choice of career came down to medicine or engineering not because of any particular interest of Hingorani's, but because those were the only professions that yielded a reasonable income in India. His move into power engineering was similarly motivated. "I could have gone into electronics," he said, "but where would you get a job when you graduated?" When he received his BSEE in 1953, all his job prospects were in power fields. He took the one that sounded the most interesting: the electrification of rural villages.

Power to the villages

Fresh out of college, completely inexperienced, Hingorani was handed what to many would have seemed a daunting task, but one that captured his imagination, challenged his creativity, and jolted him out of lackadaisical student habits into intense work.

"I was thrust into responsibility," he recalled. "I was told, 'Here are seven people who work for you, and your job is to electrify these villages 10 or 20 miles away.' I had to do everything: understand what was needed, take care of surveys and drawings, negotiate the rights of way, talk to the village chiefs, and decide where the lights should be and what the loads would be."

He found he had to consider things no professor had mentioned in college. For example, in rural India, farmers would often tether buffalo to the guy wires supporting power poles. "You had to design for that," he said.

Hingorani considers this period of his life to have been the most satisfying, for the villagers were so happy to see him and treated him with reverence. "I had a tremendous sense of satisfaction when the electricity was turned on for the first time," he told *Spectrum*.

His experience electrifying rural villages instilled the belief that electricity has a unique role in improving the quality of life, a belief that has become almost a religion for him.

After two years, the challenges of rural electrification became routine, and Hingorani itched to move. No promotion was in sight, and like many young men in India, he had long dreamed of going abroad. He also had the notion that perhaps there was something special about graduate education.

So he wrote to a number of professors of power engineering at British universities. One, Colin Adamson of the University of Manchester Institute of Science and Technology, replied, "Come

Vital statistics:

Name: Narain G. Hingorani **Date of birth:** June 15, 1931
Place of birth: Tatta, a village in Sind, now in Pakistan
Height: 178 cm (5 ft, 10 in.) **Weight:** 77 kg (170 lb)
Family: married, two children
Education: BSEE, Baroda University, India; M.Sc. and Ph.D, University of Manchester's Institute of Science and Technology, England
Memberships: National Academy of Engineering, IEEE, Conference Internationale des Grands
Awards: IEEE Fellow; IEEE Uno Lamm Medal; American Society of Materials International Engineering Materials Achievement Award
Patents: about 15
Favorite books: novels about India
Favorite periodicals: *EPRI Journal*, *IEEE Power Engineering Society Transactions*, *CIGRE Electra*
Favorite country to visit: India
Favorite food: Indian, French
Favorite restaurant: Su's Indian Cuisine in Mountain View, Calif.; Beauséjour in Los Altos, Calif.
Languages spoken: English, Hindi, Sindhi, a bit of Russian
People you most respect: Chauncey Starr (first president of EPRI), Uno Lamm (HVDC pioneer), his father
Leisure activity: long walks with his wife, gardening, visits to Lake Tahoe
Biggest surprise in career: "Discovering I had the potential to be somebody"
Management credo: "In R&D, you must think cradle to grave, to see the end use"

Tekla S. Perry Senior Editor

0018-9235/90/1200-0061$1.00©1990 IEEE

at once." In 1955, Hingorani moved to England.

He embarked on ■ Ph.D. program of study through research, and Adamson offered him three choices: high-voltage DC (HVDC) transmission, protective relays, and dc switches. After three months, Hingorani selected HVDC transmission because the field was in its infancy and most challenging.

The topic so captured his interest that he did not dream of reverting to his earlier college habit of coasting. "I wanted to work," he recalls. "I did ■ lot of study and thinking about it."

After a year and ■ half, he had completed ■ draft of a thesis on HVDC transmission. Adamson read it and, very impressed, took it to Garraway Ltd., ■ London textbook publisher, and proposed that it be turned into a book, coauthored by Adamson and Hingorani. Funded by the advance, Hingorani worked on the book full time, and *High Voltage Direct Current Power Transmission* was published in 1960. The book described ac/dc and dc/ac conversion techniques, control and protection of HVDC transmission, overhead lines, cables—virtually every aspect of the design, development, and operation of this type of transmission system.

Bible for HVDC transmission

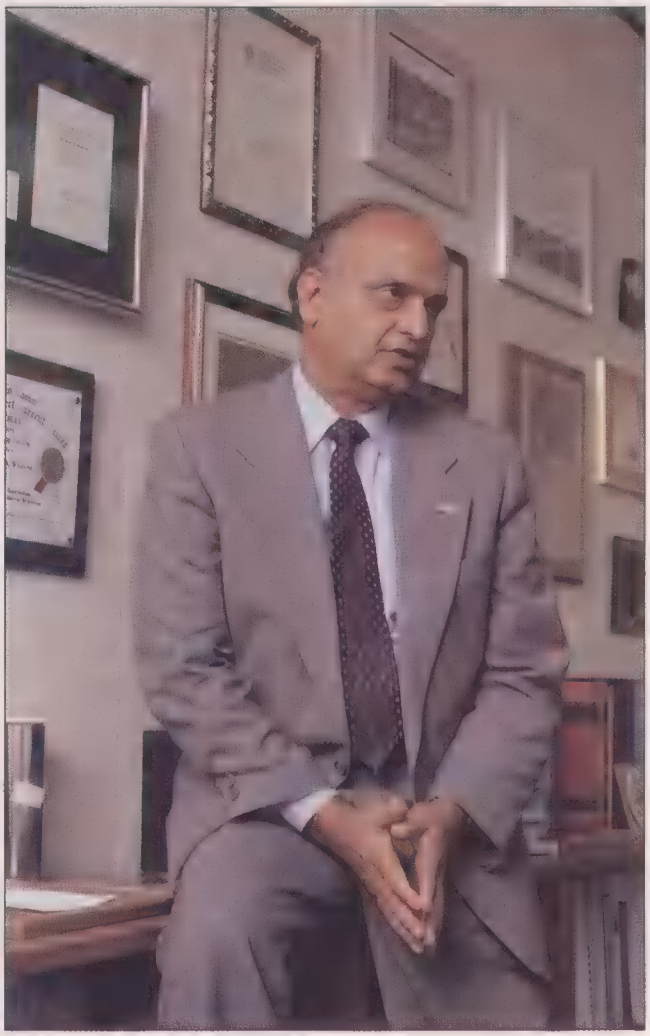
The positive reaction of his professor and his willingness to trust Hingorani with challenging tasks, the enthusiasm of the publishing company, and the acclaim from the technical community which embraced Hingorani's book as the bible for HVDC transmission, took him by surprise. For the first time, he realized that he had the potential to be ■ good R&D engineer.

"I had been in no position to judge myself," he told *Spectrum*. Even today, after decades of challenges met and countless kudos received, Hingorani seems stunned by the respect his colleagues have for his accomplishments.

"Unlike most people with his kind of capability, Nari is not at all impressed with himself," IEEE Fellow John Dougherty, retired vice president of electric systems for EPRI, told us.

After his book was published, Hingorani himself became a professor, guiding graduate students at Loughborough University and then Solford University, both in England. Like Adamson—and unlike most professors in England—he spurned Government-funded university research grants and sought funding from industry, since such ties would ensure that his work was quickly applied. He recalls this as a particularly enjoyable period during which he made a set of discoveries concerning HVDC systems that advanced the state of the art. These included the concept of transistorized control, an HVDC simulator, and a dc-measuring transformer.

Narain G. Hingorani, vice president, electrical systems, for the Electric Power Research Institute in Palo Alto, Calif., has received most of the major awards in his field during his years in electric power.



EPRI (photos)

"We worked like a family," Hingorani said. "We solved problems together, we shared certain rituals." As often as three or four times ■ week, Hingorani and his graduate students went to a local pub, the Prince of Wales' Feathers, for lunch and poker.

Go west, young man

As Hingorani was enjoying the academic life, many visitors came to talk to him about HVDC, including Everett Harrington, engineering manager for the Bonneville Power Administration (BPA) in Portland, Ore. Harrington read Hingorani's book while traveling to Sweden for the first time to discuss acquiring HVDC transmission technology, and he was so impressed that he offered Hingorani work on the northern end of the HVDC Pacific Intertie, ■ 1350-kilometer transmission line that would bring cheap hydroelectric power from the northwest United States to southern California and return power to the Northwest whenever rivers there were low. This was to be only the third—and by far the longest—HVDC transmission system in the world.

Hingorani had no desire to leave his university post, but thought he would try working at BPA during his annual three-month vacation in 1967.

"I was totally taken by the majesty of nature in Oregon," he recalls. "I fell in love with the state." He also was impressed with BPA: for ■ Government organization, he believed, BPA had found a way to be efficient despite the Washington, D.C., bureaucracy, valued getting things done, and was managed by engineers who had pride in being first in the use of advanced technology.

By then, Hingorani had married and had two children. Packing up his wife Joyce, his 10-year-old son Naren, and his 3-year-old daughter Devi, Hingorani relocated permanently to the United States.

He thought he had been hired by BPA to work in some trouble-shooting capacity on the Pacific Intertie project. After all, his title was "Consultant, HVDC system." "I assumed that I would be helping on specific problems as they arrived," he said.

Instead, he was put in charge of managing the construction, testing, and placing in service of the Celilo Terminal at the northern end of the Pacific Intertie—"one of the most complex electric power installations in existence," BPA's Diemond said.

"Almost all the problems were mine," Hingorani recalls. It was a replay of the rural electrification project, magnified thousands of times.

In 1974, Robert Perry from EPRI, a nonprofit research consortium of some 660 U.S. electric utilities, called Hingorani and offered him a job as a program manager, responsible for US $5 million to $10 million annually in R&D projects concerning ac and HVDC substations.

Hingorani accepted the post, and moved to Los Altos Hills, Calif., less than a mile from EPRI's Palo Alto offices. But it was about four years before he stopped wondering if he had made ■ mistake. He enjoyed his job at EPRI—for the first time,

he could launch about any research project he thought important—and he found that he liked R&D management, for it gave him the chance to realize much broader visions than he could as an individual researcher. But he had sacrificed the Oregon forests to fast-paced, high-pressure Silicon Valley. Today, however, he is proud to be part of EPRI, which he considers the best R&D organization in the world.

In 1971, Hingorani (standing) and U.S. experts on transmission technology met their USSR counterparts to start an effort in international cooperation that continues to this day.

Entrepreneur manqué

Hingorani had often wanted to start his own business. His father had been a powerful role model in this: he had once been a civil engineer, but had abandoned that career completely after being forced to take a bribe, and resolved never to work for anyone else again. Hingorani's four brothers have all at one time been in business for themselves and only Narain has never struck out on his own.

"That I haven't is one of my biggest regrets," he told *Spectrum*.

Since his days as a professor in England, he had done part-time consulting, the seed for a full-time business he could expand into a small company with several employees. Whenever Hingorani holds a job for five years, he begins to think about an entrepreneurial launch—which happened a couple of times during his tenure at EPRI. "I said to myself, 'Now let me chuck it and go into business,' " he recalled. But each time his plans were interrupted with promotions.

In 1986, Hingorani moved up to vice president, electrical systems. The six EPRI vice presidents together are responsible for US $350 million annually in research and development, mostly through contracts. This, Hingorani says, is as high at EPRI as he could go. He has six more years until his retirement at age 65, and then he will definitely go into business.

Hingorani attributes much of his success to this willingness to pick up and go after new challenges. "I have lived so many lives," he said. "If I had stayed in one place, I would have lived only one life."

His former boss, Dougherty, sees an additional reason for his success: the depth of his technical knowledge in any aspect of power engineering. Hingorani reads trade journals religiously, and, according to Dougherty, he must be an incredibly fast reader.

"I've spent 40 years in the power business," Dougherty said, "and I never met anyone who seems to know as much about everything as Nari does." Dougherty recalls that whenever any new technology, like higher-temperature superconductivity, came up in discussion at an EPRI staff meeting, Hingorani would have information about the technology that no one else was aware of.

Family comes first

Although typically very serious on the job—except when his face suddenly lights up in laughter—he lives by a philosophy that he tries to impart to his employees: work is not a matter of life and death. "All that is expected from people at the job is that they give their best. If something I did turned out not to be right, I'll shrug my shoulders; that is as far as I will go. I don't carry a sense of anxiety beyond that."

Work should come second to family, Hingorani believes. "When people are young and full of fire, they get keyed into a profession and everything else becomes secondary," he said. "You have to remind them that that is not right; they have to consider home and family."

Today at EPRI, Hingorani said he thrives on managing R&D. "If I have an idea for a major strategy to create a power system technology of the future, I couldn't do it on my own," he explained. "With this organization, I can say this is how I see things 20 years from now; these are the pieces that need to be worked out, and I have the people and the resources to make it happen." In fact, he sees himself as somewhat of a venture capitalist investing EPRI's dollars: he is trying to launch R&D that will lead to new businesses, and he looks for researchers who could spark such enterprises.

Most recently, he has started research into a transmission strategy that he calls "Flexible ac transmission systems" (Facts), which he believes will have a big impact on power systems in the future. Facts is a method of doubling the usable capacity of today's transmission lines by pushing them, safely, to their maximum thermal limits, using solid-state controllers, high-speed communication links, and automatic computer control.

In his post as an EPRI vice president, Hingorani spends much of his time conveying his ideas to utility executives. For this he has had to learn new styles of communicating. "You cannot explain in detail and finally get around to what you want to say when dealing with executives," he said. "You need to be prepared with the key things, to be concise. My boss Richard Balzhiser, president of EPRI, keeps reminding me that I need to stand back from being an engineer, not explain everything, but figure out what is important to the executive, what he is thinking, and address him in those terms."

Today, Hingorani is concerned that attempts to encourage conservation by raising gasoline and oil prices might lead to increases in the cost of electricity as well. "It is vital to recognize that electricity is unique among energy sources: low-cost power is vital for a better life. Electricity gives us economical lighting, computers, television, microwave communications, and medical technologies—things that would not be possible without it."

If Hingorani were a sophomore college student today, facing the same dilemma as he did in 1950, he said, he would not have to flip a coin—because now there is a field that combines medicine and engineering: biotechnology. "I am fascinated by that field," he told *Spectrum*. "If I were a young person now, it would clearly be the most incredible area to go into. I would be working on how to prolong life."

To probe further

For a detailed history of the Pacific Intertie project, see "The Pacific Intertie," by Glenn Zorpette, *IEEE Spectrum* 25th Anniversary issue, 1988. ◆

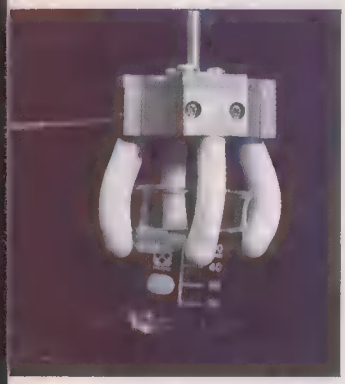
Japan robotics aim for unmanned space exploration

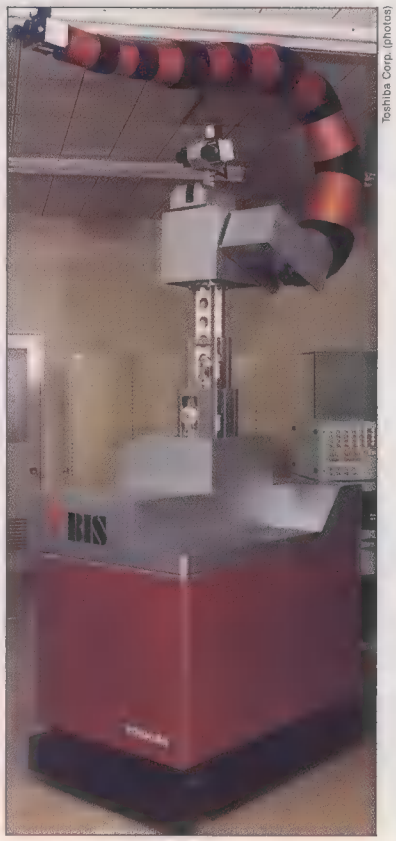
Government, industry, and university leaders have embarked on cooperative projects to develop next-generation robots for space

Last May, seven prominent U.S. roboticists crossed the Pacific to examine the latest Japanese research applicable to unmanned space endeavors. Their grueling schedule covered 30 facilities, but exposure to the latest Japanese robotics research—some of it quite innovative—was enthusiastically described as ample compensation. William L. ("Red") Whittaker characterized their intense immersion as equal to a master's degree. Their study, sponsored by the National Science Foundation and the National Aeronautics and Space Administration's Automation and Robotics Program, was prepared for the U.S. government's program evaluating Japanese technology. It is scheduled for release this month. What follows is an account exclusive to IEEE Spectrum *of the findings of the Japanese Technology Evaluation Center (JTEC) panel by its two cochairmen.*—Ed.

Japan's space program, though currently dwarfed by those of the United States, Europe, and the Soviet Union, has an unencumbered vision. It recognizes the enormous expense of manned space operations and intends to minimize this cost, as well as spur technology, by developing a range of automated machines.

The Space Robot Forum, a prestigious 70-member group from Government, industry, and academia, funded by the National Space Development Agency (Nasda), recently outlined an ambitious schedule for "third-generation" space robotics. Already, some very impressive and often novel work is occurring in industry and Government laboratories and Japanese robots are now employed in construction projects on land and under water, gaining experience that may be applicable in space. Although our JTEC study made no formal attempt to compare the status of Japanese and U.S. robotics research, it is clear that the United States could benefit in some areas by cooperative research with Japanese colleagues.





Toshiba Corp. (photos)

Rubber fingers (above), controlled by varying the pressure inside hollow segments, and a robotic arm akin to an elephant's trunk (right), developed for nuclear power applications, may find use in space. The fingers can even screw nuts onto bolts.

Some ambitious goals

Like many space powers, Japan plans to expand its frontiers and develop its own large rocket, shuttle, and space station, and explore the moon and then Mars. Many of the tasks will be done by machines, a progression from teleoperation (in which robotic devices are to a large extent remotely controlled by humans) to telerobotic operation (where robots do simple tasks on their own) to the third generation devices (where machines work without much, if any, human intervention).

The first launching of Japan's Hope Shuttle is planned for the mid-to-late 1990s. Hope is to be unmanned, but otherwise similar in function to the U.S. shuttle. Its main functions will be transport and serving as a platform for experiments. Also, Hope will dock with space structures and satellites.

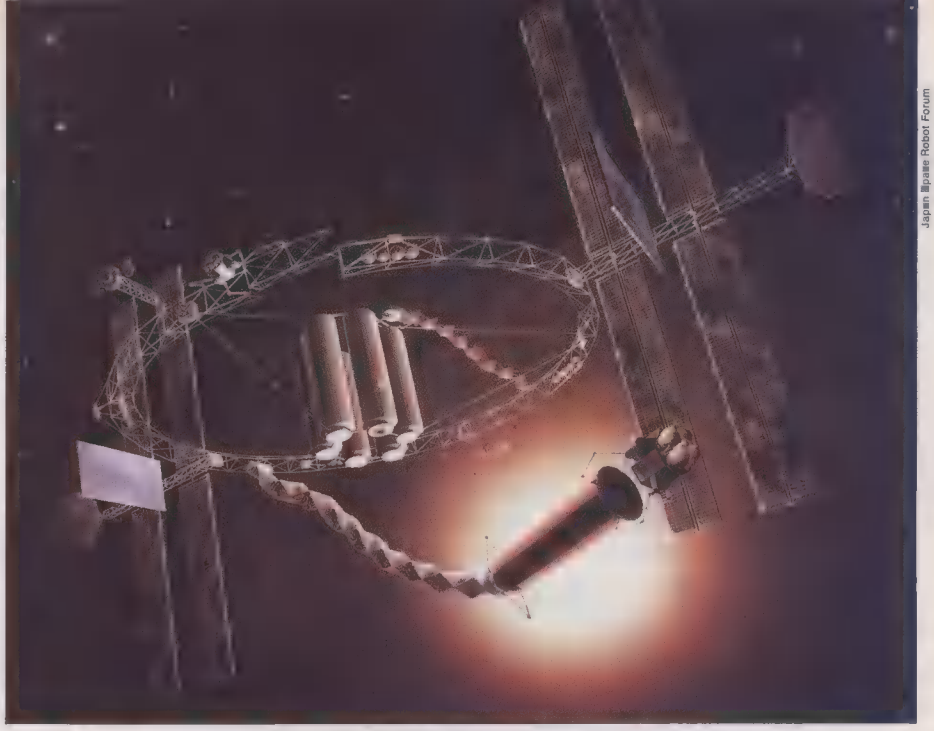
As part of the Japan Experimental Module of the U.S. space station Freedom, planned for launch by NASA in the mid-1990s, Japan is developing a 9.7-meter-long robot arm capable of maneuvering a payload with a mass of 7000 kilograms. At the end of the long arm will be a smaller arm and gripper for more dexterity [see lower photo on opposite page]. Current U.S. plans include nothing like this mix of arms, which has a projected launch date of 1997.

The Space Robot Forum envisions Japan's own Cosmo-lab space station as an unmanned, low-earth orbit station assembled, operated, and maintained by earth-controlled robots [see photo, top right]. Among other things, it is to use a free-flying robot to tow satellites and cargo to the station, and a variable-geometry, or "serpent" robot with an arm of at least 25 meters. Six launches of Japan's H-II rockets, each capable of lofting 10 tons, should be enough to lift all the station components into orbit.

Although key technologies must be developed for Cosmo-lab and no funded work is currently under way on this project, the Japanese are likely to apply technology from first- and second-generation space robots and those developed for earth applica-

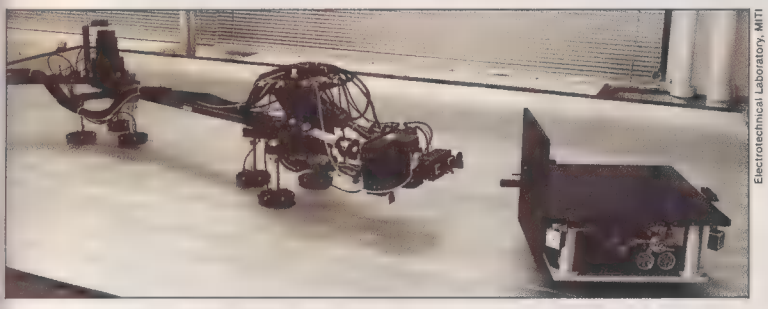
William L. Whittaker and Takeo Kanade
Carnegie Mellon University

0018-9235/90/1200-0064$1.00 ©1990 IEEE



Japan Space Robot Forum

Japan's Space Robot Forum, a prestigious 70-member group funded by the nation's space agency, envisions an unmanned space station with snake-like robots of at least 25 meters attached to a ring (right) and other machines that fly freely. Innovations for Japan's module on the U.S. manned space station Freedom include a long arm ending in a dexterous small armed manipulator (below).



Electrotechnical Laboratory, MITI

tions. Overall, Cosmo-lab has important implications for the future of space assembly.

Some 10 years from now Japan plans to launch an unmanned Orbital Servicing Vehicle to inspect, assemble, and repair satellites. Several concepts for the vehicle exist; key technologies, however, still need to be developed in sensing and perception, autonomous control, manipulation, and teleoperation. Eight organizations are working on the vehicle under Nasda's lead. In the mid-1990s, Japan will try to retrieve a special satellite by an unmanned "Space Flyer Unit." This should demonstrate techniques useful to OSV development, such as the coupled control of a free-flying vehicle and its manipulator.

Last May, Nasda announced a three-part lunar mission in which robots are to play a large role. Projected for launch in 2000, the unmanned Lunar Mobile Explorer (LME) is the first part of the mission. The 900-kg telerobot will investigate soil characteristics, collect and deliver samples, and determine whether water is present under the moon's permanent shadow. In the second phase, scheduled for 2010, the Japanese plan to establish a manned outpost mission. Settlement on the moon would constitute phase three.

Array of robots

The moon mission is the first where the Japanese envision roving about an extraterrestrial surface. Extreme environmental conditions—including wide temperature ranges, radiation, lower gravity, and rough terrain—will require a unique class of robots. These surface robots must move in hard or soft terrain, remain upright or be able to right themselves, and be physically self-contained in terms of power supplies, sensors, and computers. They must also be durable, highly independent of human control, and capable of exploration and construction.

Currently, the Japanese are not developing lunar exploration robots. But R&D for mobile robots does exist, stemming from areas other than space. Several combination wheeled-and-tracked robots, for instance, are in Japan's repertoire and more are on their way.

Mitsubishi Electric Corp., Tokyo, has a series of articulated track vehicles. The latest is the MRV3, which (like a child's dream toy) can metamorphose into any of three locomotion modes. In its wheeled mode, the robot drives in forward or reverse like any car. Also, by swinging its four wheels around the frame's corners (in the position of a car's front and rear bumpers), the robot moves sideways in either direction. Or, by moving the wheels to the corners of the frame, the robot can rotate in place.

To convert to mode two—the tank mode—the robot lowers four tracks 90 degrees so the tracks are horizontal. (In the wheeled mode, these tracks stand upright beside each wheel.) The robot can thus crawl up stairs or cross ditches. To switch to mode three—the walking mode—the robot lowers its tracks 180 degrees so they become four long stilts. Now it can stand high or stride over obstacles.

All three locomotion modes are accomplished using a newly developed drive mechanism of one motor, three shafts, and three clutches for each locomotion apparatus. If it can be adapted for hazardous environment work, the system may eventually be suitable for planetary exploration.

The Mechanical Engineering Laboratory of the Ministry of International Trade and Industry (MITI) at Tsukuba has developed an active suspension system that may find use in future space rovers. Its robot's four wheels rise and fall independently of one another with terrain. The platform is more stable over rough landscapes (and tips over less frequently) than traditional wheeled systems. For maintenance tasks within modules on a moon or Mars base, Hitachi's small, wheeled-and-legged robot made for nuclear power plants could be relevant.

Although most land animals move on legs, mechanical systems are far from approaching the great efficiency of horses and mules over rough surfaces. Though more attention has been devoted to wheeled systems, Japan is redressing that with some of the best research on walking robots with two or more legs. Their high maneuverability and efficiency make these robots prime candidates for planetary operations.

Japan's Port and Harbor Research Institute has been improving its Aquarobot over the last eight years [photo, p. 66]. It's a six-legged system teleoperated for inspection as deep as 50 meters under water (an environment with similarities to space). Other

walkers include a Tokyo Institute of Technology quadruped that can move across uneven surfaces under autonomous control while keeping its body level [photo, p. 67], and Toshiba's small, crablike robot for inspecting areas such as nuclear facilities.

Because of its dense population and limited land mass, Japan is exploring underground and undersea frontiers. Many of these technologies may be adaptable to space exploration and construction.

A seven-year project called Underground Space Development Technology began this year to devise technologies for building underground energy storage and supply systems, as well as cultural and commercial facilities. Already, Shimizu Corp., Tokyo, the world's largest construction corporation, has designed an automated excavator capable of digging a hole 3.2 meters wide and 150 meters deep. Another company, Komatsu Ltd., Tokyo, uses a huge, teleoperated robot underwater to level about 40 square meters of rubble each hour. The heights of the machine's legs are adjustable, and it levels large surfaces to an accuracy of less than 0.3-meter grade difference.

Shimizu has also formed a research team devoted to lunar base construction. Its scenario is to build a base on the moon using lunar materials and automated machinery. Plans call for the base to be a lattice of modules constructed from concrete produced on the moon. The concrete walls will be reinforced with cables to handle indoor air pressure. Extensive testing on the performance of concrete on the lunar surface has been undertaken by Shimizu and methods for hydrating the cement in the lunar environment are being developed. Construction of this base is to be performed as far as possible by robots, under teleoperation.

Some novelties

The JTEC team saw a number of novel mechanisms. Japan is already the dominant manufacturer of commercial robot arms for standard industrial assembly or transfer of assembly-line pieces. Its researchers are now developing more flexible manipulators akin to snakes, tentacles, or elephant trunks that hold great potential for space applications. Their long reach, narrow profile, and ability to conform to complex shapes allow such serpentine arms to, say, inspect pipe interiors or work on hard-to-reach components in nuclear reactors.

Perhaps the most comprehensive system is Toshiba's multijointed inspection robot [photo, p. 64]. It incorporates continued development in mechanics, sensing and control, signal multiplexing, and user interface. The arm consists of eight joints, each with two degrees of freedom, that are linked serially and decrease in size toward the tip of the "trunk." A low-weight actuation system uses components of titanium and composite materials. The arm is integrated with a mobile platform.

Other serpentine systems include Hitachi's nuclear containment-vessel inspection robot, Fuji Electric Co.'s 7.2-meter-long manipulator for nuclear inspection, and Osaka University's truss-type parallel manipulator. The segmented serpentine shape is also used for locomotion in robots, such as those at the Tokyo Institute of Technology [photo, p. 67].

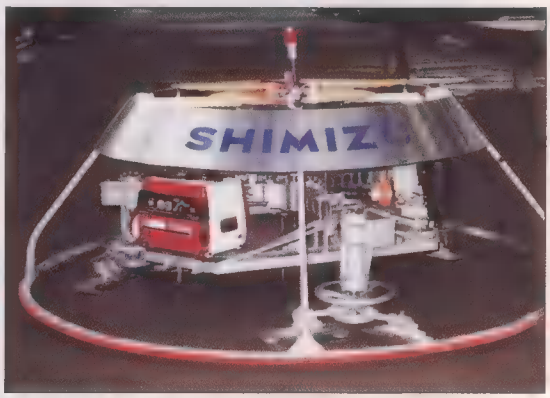
Toshiba has also devised some very interesting flexible fingers controlled with pneumatic servos [photo, p. 64]. Each finger is a hollow rubber cylinder divided lengthwise into three chambers that can be pressurized independently. By varying the pressures in each chamber, the pliant fingers can gracefully grasp a beaker from the exterior as human fingers might, or approach it from the interior and bend backwards to grip it. The main advance is the design of the cylinders to correctly repeat the movements as the pressurization changes and to stand up to constant pressurization. The fingers, controlled through joysticks without feedback sensors, can even remove nuts from bolts.

The Japanese have excelled in the development of focused, special-purpose systems, some of which may find applications in space. These include a ladder-climbing robot by Toshiba; a teleoperated live-powerline maintenance robot by Yasukawa; bipedal walkers developed by Tokyo's Waseda University; and Sesara, Matsushita's advanced two-arm torso that can stitch together a purse on a sewing machine, turn it inside out, and attach a shoulder strap. (Done crudely by human standards, this is state of the art with two-handed cooperation and sensory feedback.)

In addition, Toshiba has developed ARI, an assembly robot intelligent enough to study and complete an assembly task. A videotape shows the two-armed robot visually finding, grasping, and putting together Lego blocks without human intervention [photo, p. 67].

The move toward applications-oriented systems can also be

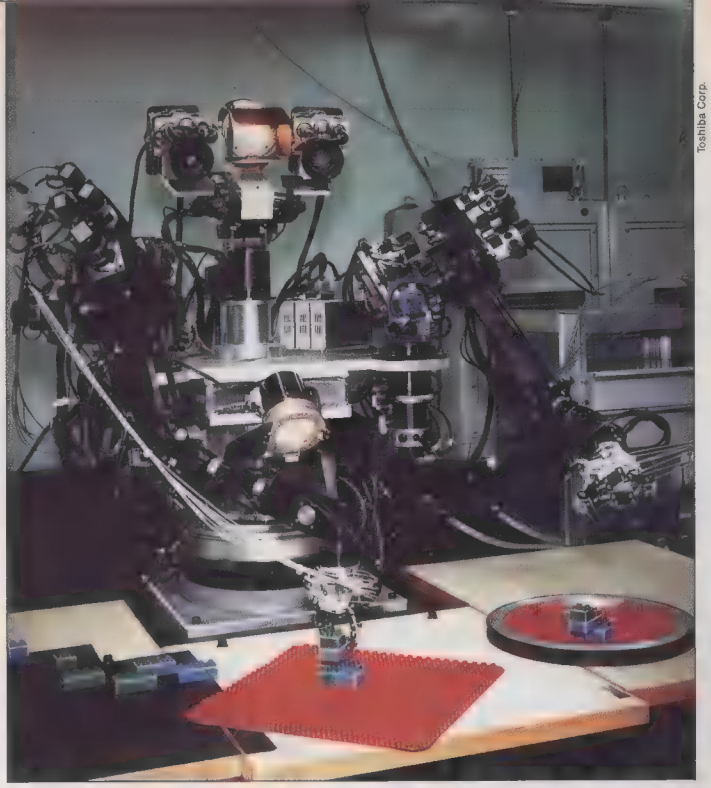
Kajima Corp.



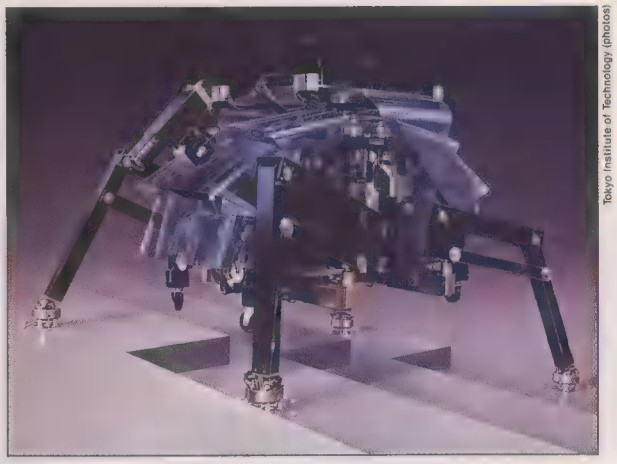
Shimizu Construction Co.


Port and Harbor Research Institute

Robots are already being applied in Japanese construction: to put up walls, smooth wet concrete floors, and check undersea foundations. Such tasks may be useful for automated construction on the moon or Mars.



Toshiba Corp.



Tokyo Institute of Technology (photos)

Japan's impressive depth and range of research yields (clockwise from above) a two-armed torso for the study of assembly operations, a four-legged walking robot, and a caterpillar-like segmented machine.

seen in Waseda University's Breast Palpation Robot, which softly detects breast tumors with 25 sensors, and in Waseda's "humanoid" fingered robot, which reads music and plays a piano.

Looking far into the future, the Japanese feel that automation in space will be a huge enterprise. Thus they show a willingness to invest in long-term space robotics to develop a vast technological base from terrestrial work.

Quite a few companies that participate in space robotics have both a space division and an industrial robot division. These include Toshiba, Hitachi, Mitsubishi Electric Co., Fujitsu, NEC Corp., Mitsubishi Heavy Industries Ltd., and Kawasaki Heavy Industries Ltd. The first three companies build and maintain nuclear reactors, so they have additional incentives to develop robots for hazardous environments. There are also quite a few robot-user companies, such as Shimizu Corp., Komatsu Ltd., and Kajima Corp., Tokyo, whose skills may be useful in future space exploration or construction.

The Japanese Government's infrastructure for space development is analogous to the United States'. Various Government agencies—MITI, Nasda, the Ministry of Education's Institute of Space and Aeronautical Science—set policies, distribute funds, and determine the direction of projects. Private companies obtain contracts to develop systems. But, as in other areas, the Japanese Government often provides seed money and industry contributes significantly to the funding of research projects.

Since 1983, MITI has sponsored an advanced robotics program to devise a nuclear-powered robot, a subsea robot, and a disaster/firefighting robot. Twenty organizations (18 companies and two research laboratories) are collaborating. Next year, MITI plans to begin a "micro robots" initiative that may be relevant to space, and it is also considering a space robot initiative. During the JTEC visit, a MITI official proposed cooperating with NASA on space robotics, and the two agencies have begun discussing a joint project.

Since this was the first-of-a-kind portrayal of Japanese space robotics, overall, the JTEC space robotics endeavor should benefit agencies and researchers in both the United States and Japan. Possible future activities include similar studies for the United States and Europe/USSR, a biennial or triennial update of the Japan study, and cooperative or coordinated Japan-U.S. space robotics activity.

To probe further

The 263-page JTEC space robotics study to be published this month includes schematics, contacts in Japan, and references. To order, contact the National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, Va. 22161; 703-457-4650. A videotape, spliced together from many facilities, highlights many robots described in action. It is also available from NTIS. Another, longer videotape, narrated by William L. Whittaker, is available for US $37.50 from University Video Communications, Box 20006, Stanford, Calif. 94309; 415-327-0131. For more information on Japan Technology Evaluation Center (JTEC), Loyola College, Baltimore, Md., contact the National Science Foundation, Washington, D.C.; 202-357-9498; or Duane Shelton, Loyola College, Baltimore, Md. 21210.

About the authors

William L. ("Red") Whittaker, principal research scientist at the Robotics Institute at Carnegie Mellon University, Pittsburgh, directs its Field Robotics Center. He received his B.S. from Princeton and M.S. and Ph.D. from Carnegie Mellon.

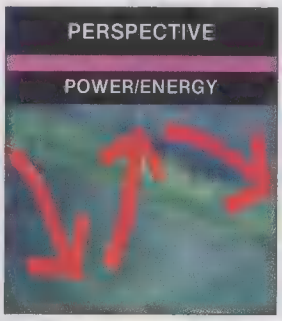
Takeo Kanade, a professor of computer science at Carnegie Mellon, is codirector of its Robotics Institute. He received his Ph.D. in information science from Kyoto University, Japan. He is an administrative committee member of the IEEE Robotics and Automation Society. ◆

Acknowledgments

The authors' very open and cooperative hosts in Japan made this study possible; so did the other JTEC panelists: James W. Lowrie, Martin Marietta Corp.; Harry G. McCain, NASA Goddard Space Flight Center; Antal K. Bejczy, NASA Jet Propulsion Laboratory; Thomas B. Sheridan, Massachusetts Institute of Technology; Peter Allen, Columbia University; and Melvin D. Montemerlo, NASA's Office of Aeronautics and Space Technology.

Fish and hydroelectricity: engineering a better coexistence

Under pressure from a Federal licensing agency, U.S. utilities are helping restore once-vast populations of migratory fish



The power of falling water did much to launch the industrial age and continues to supply a significant fraction of the world's energy needs. The reasons for this endurance are many, including hydropower's renewability, lack of pollutant emissions, and exceptionally low production costs.

But in other than financial terms, the costs of hydropower have been high. On rivers from New Zealand to New England, once-vast populations of migratory fish—including salmon, trout, and shad—have been sharply reduced, in some cases to virtually zero.

Waterways designed to help migrating fish get past dams to upstream spawning areas have been used on some rivers for decades. More recently, however, Federal wildlife officials and conservation groups in some areas—especially North America, New Zealand, and Scandinavia—have become convinced that further progress in restoring some fish species depends on getting larger numbers of the offspring, and adults that survive spawning, *downstream* past the dams. In these areas, hydroelectric plants are increasingly being planned and operated with the advice, if not active participation, of wildlife, conservation, and native groups interested in protecting or improving fish populations.

"For virtually every hydroelectric plant up for licensing today and in the recent past, the interests of fish and wildlife agencies have been a paramount issue," said Fred E. Springer, director of the U.S. Federal Energy Regulatory Commission's Office of Hydropower Licensing in Washington, D.C. In an interview, Springer added that in the United States, some 170 hydroelectric plants, representing roughly 2000 megawatts, must apply for relicensing by Dec. 31, 1991.

The utilities that operate these plants are finding that accommodating migrating fish presents unique engineering challenges, not the least of which involves designing and building systems to protect fish species whose migratory behavior remains something of a mystery. Where such systems cannot be built, the status of hydroelectric dams may be in doubt, as is now the case with several dams in the United States. A further twist in some regions is the possibility that certain migratory fish will be declared threatened or endangered—a development that could wreak havoc on the hydroelectric energy supply in those regions.

Changing regulations

The issue is most contentious where hydroelectricity and conservationism are both pervasive—in Canada and New Zealand, for instance, where hydroelectricity meets about 60 percent and 75 percent of demand, respectively. Canadian hydroelectric plants, historically under provincial jurisdiction, are now subject to "more involvement at the Federal level as well," especially where migratory fish are impacted by them, noted Alan D. Christie, supervisor of sciences and field studies at Ontario Hydro in Toronto.

Glenn Zorpette Associate Editor

In New Zealand, the jurisdictional movement is in the reverse direction, but with the same intent. A 600-page Resource Management Law Reform Bill is expected to shift responsibility for approving dams and other water obstructions from the national government to regional councils, giving them statutory powers to impose minimum standards for flow rates, water quality, and fish protection. The councils can reject dams that they believe could irreparably damage the aquatic environment.

Hydroelectricity meets only about 10 or 11 percent of demand nationally in the United States but is the mainstay in certain regions, most notably the Pacific Northwest, where it meets 64 percent of demand. Using computer models and 19th century records from commercial fisheries, biologists have estimated that as many as 16 million salmon returned annually to spawn in the region's mighty Columbia River before development began in the mid-1800s; that number has been reduced to about 2¾ million today. The loss of so many fish has been attributed primarily, but not solely, to hydroelectric development; other factors known to adversely affect these anadromous fish populations include commercial fishing, logging, mining, and irrigation.

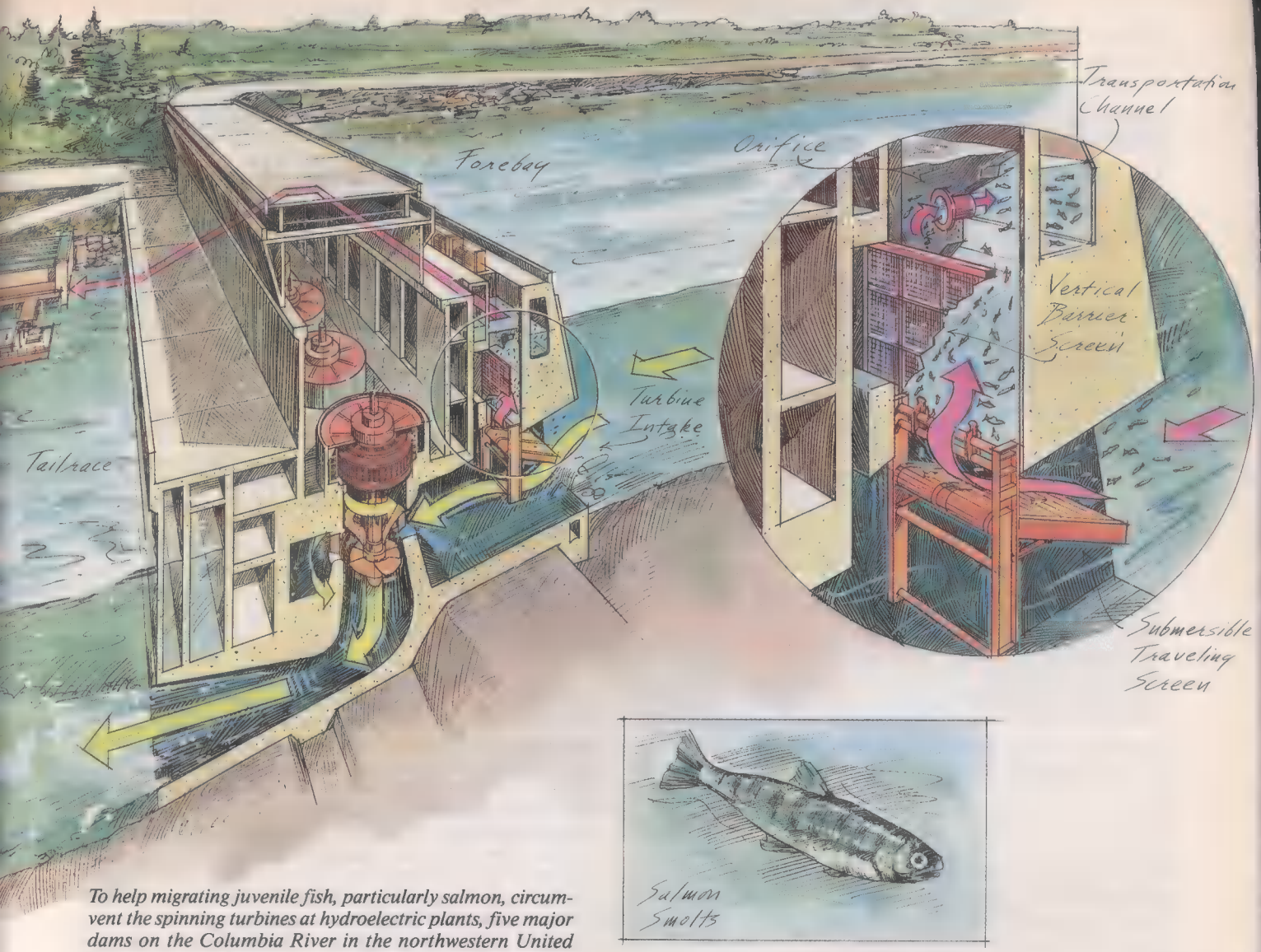
As far back as the 1930s, amendments to the Federal Power Act gave the U.S. Secretaries of the Interior and Commerce the right to prescribe "fishways," or systems for getting fish around hydroelectric dams. Later legislation expanded the role of Federal and state fish and wildlife agencies, and today, they can recommend that such systems be installed at the dams as conditions for licensing or relicensing. The Federal Energy Regulatory Commission (FERC), which issues the licenses, must adopt the agencies' recommendations if they do not conflict with Federal laws.

Different types of fish present different problems for hydroelectric developers, but the most difficult are associated with anadromous fish such as salmon and shad. Hatched in fresh water streams and rivers, these creatures spend most of their lives in the ocean before returning to the rivers where they were born to spawn and then, typically, die. In New Zealand, concern has also been raised about certain eels, which are catadromous, spawning in salt water but spending much of their lives in fresh water.

Since the 1930s, operators of hydroelectric plants in various countries have tried to help anadromous fish move upstream past dams with a series of inclined, connected waterways, or fish ladders. These ladders have generally been a success in the United States, Canada, Europe, the Soviet Union, and Japan but not everywhere else; in New Zealand, for example, 12 of 33 hydroelectric dams have fish ladders but only 5 of them work, according to an official of the country's Ministry of Agriculture and Fisheries in Wellington.

In the United States, fish and wildlife agencies have recently been insisting that utilities make more strenuous attempts to convey juvenile anadromous fish downstream, a much more difficult challenge than getting their parents upstream. "Over the last two decades, we expended considerable effort trying to get fish

0018-9235/90/1200-0068$1.00©1990 IEEE



To help migrating juvenile fish, particularly salmon, circumvent the spinning turbines at hydroelectric plants, five major dams on the Columbia River in the northwestern United States have been equipped with submerged traveling screens. Installed in front of the turbine intakes, the screens rotate like conveyor belts to clear themselves of debris, while diverting fish to a bypass route, or "transportation channel," that takes them past the turbines to the downstream side of the dam. (Magenta arrows indicate the route of the fish; the direction of water flow is shown in yellow.) So far, the screens have been installed at Bonneville, John Day, McNary, Little Goose, and Lower Granite dams, at a cost of more than US $100 million.

upstream," said Benedetto Rizzo, ■ hydraulic engineer at the U.S. Fish and Wildlife Service in Newton Corner, Mass. "But now we've turned the corner. We have them coming upstream, and we find one of the limiting factors to our restoration efforts is the ability to get fish downstream."

Downstream difficulties

Most of the large dams in the U.S. Pacific Northwest are Federally owned and operated, primarily by the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation, and as such are not subject to licensing. Nonetheless, the region's dependence on hydroelectricity and strong conservationist sentiments have combined in recent years to make the Columbia River Basin an important proving ground for systems and techniques designed to protect or enhance fish populations. In fact, the Federal dams on the Columbia are the only ones in the world for which a sizeable body of operational experience has been assembled using downstream fish-passage systems.

A key player in this activity is the Bonneville Power Administration, ■ Portland, Ore.-based Federal agency that markets Columbia River hydroelectricity. Bonneville is also the largest source of Federal funds for restoration-related research in the region, spending nearly US $85 million annually on improving fish hatcheries (where most of the region's salmon are now born), curing maladies suffered by the fish, and generally making the river more fit for habitation. The Corps of Engineers leads in the design and construction of systems for downstream passage, but Bonneville participates in and helps pay for the work.

Bonneville's and the Corps' activities are part of a larger effort, involving other Federal and state groups, to nearly double the number of adult salmon returning annually to the Columbia, to about five million. The master plan for this endeavor was formulated by yet another local organization, the Northwest Power Planning Council in Portland, Ore., an interstate compact formed by the U.S. Congress in 1980. The council was charged with the formidable task of drawing up a comprehensive power and wildlife plan incorporating the diverse views and needs of the region's state agencies, 13 Native American tribes, and other interested parties, and then of presenting the plan to Federal agencies.

Within this comprehensive plan are initiatives to aid certain salmon species whose losses have been severe. The National Marine Fisheries Service, Silver Spring, Md., is now considering whether to list several of these species as threatened or endangered; the species include the chinook that spawn in the Snake

River, the Columbia's main tributary, and certain types of coho. Initial decisions will come next spring, and most observers expect significant ramifications if the fish are listed.

"This is a big issue," Doug Arndt, a fisheries biologist with the U.S. Army Corps of Engineers, told *IEEE Spectrum*. "It has the potential to change the way we operate the entire Columbia River hydropower system."

Stunning turbulence

Federal and state programs are focusing on the juvenile salmon, or smolts, which are swept downstream by the millions in some rivers during the spring and summer. At most hydroelectric installations, these fish must pass through the turbines, where they can be injured by violent turbulence and pressure changes, making them vulnerable to predation. (Contrary to popular belief, relatively few fish are killed by contact with the turbine blades, many of which rotate at only 70–90 revolutions per minute.) No one knows the percentage of smolts killed at each hydroelectric plant that lacks provisions for downstream passage, but 10–20 percent is an estimate widely cited by fisheries agencies and utilities. On rivers with significant hydroelectric development, however, the cumulative losses can be high. For example, on the Columbia and Snake rivers, some juveniles have to make it past as many as nine dams to reach the Pacific Ocean.

A variety of techniques help as many juveniles as possible make it to the ocean. The most important ones, it turns out, are also the most fundamental: last year, for example, roughly 21 million juveniles caught above the big dams on the Columbia were simply transported in a fleet of barges downriver past the dams.

Another important technique is "spilling water," or diverting it around or over the dams from spring through midsummer, when the juveniles are migrating. Since it does not go through the turbines, spilled water means lost hydroelectric revenues. Bonneville estimates that these lost revenues, plus the costs of research related to fish protection, will add up to about one billion US dollars for the decade starting in 1981.

In hopes of reducing the amount of water that must be spilled each year, ambitious projects seeking alternative means of downstream passage are now being built, tested, or studied by Bonneville, the Army Corps of Engineers, and the Electric Power Research Institute (EPRI) in Palo Alto, Calif. On the Columbia, five major dams—Bonneville, John Day, McNary, Little Goose, and Lower Granite—have already been equipped with submerged traveling screens, at a cost of more than US $100 million (planned improvements are expected to add another US $40 million). These screens are mechanical devices that are installed in front of the turbine intakes and rotate like conveyor belts to clear themselves of debris [see illustration on page 69]. They are designed to divert most fish to a bypass channel, where they can move past the turbines to the downstream side of the dam.

The main problems with the screens are their high cost and inconsistent performance. Each costs about US $100 000 and weighs 30 tons. Dozens may be needed at a single dam, depending on the number of turbines. The screens have worked well at McNary Dam, where operators believe that the screen diverts at least three-quarters of the juveniles swimming downstream. But at the new powerhouse at Bonneville Dam, the same basic screen design has been only about 20 percent effective.

The Corps of Engineers' Arndt believes the discrepancy is due to differences in turbine-intake configuration, fish species, and even riverbed topography in front of the intakes (topography strongly affects the flow through the turbine).

Engineers are now experimenting with a screen that extends twice as far (12.3 meters) down into the water in front of the intake. This type of screen is being considered for installation at The Dalles, the last unscreened Corps of Engineers dam on the Columbia. The Corps had resisted pressure from the U.S. Congress and the Northwest Power Planning Council to install the screen, arguing that its inconsistent performance and the exceptional width of The Dalles, with 66 turbine-intake slots, would make the project impractical. However, in its 1991 budget, Congress has set aside funds to pay for the design of the project, which the Corps estimates will cost US $80 million. Designs are also underway for two other unscreened Corps dams, Ice Harbor and Lower Monumental, both on the Snake River.

Dams at risk

As a possible supplement to the screens, EPRI and other North American utility research organizations have investigated the use of underwater lights and sound generators to attract juvenile fish to a bypass area or to repel them from an intake. Although the research work was inconclusive overall, EPRI achieved promising results using strobe lights to repel juvenile shad and mercury vapor lights to attract salmon smolts and trout. The bulk of the work took place a few years ago on rivers in New England, Pennsylvania, and the Pacific Northwest.

EPRI and James River II Inc., Vancouver, Wash., have also spent US $3 million to build and test an elliptical, stainless steel screen at James River's Elwha hydroelectric project, on the river of the same name in Washington. Last June, the screen successfully diverted about 99 percent of a group of 5000 coho smolts released in the penstock on the upriver side of the dam. More tests are planned for next year. The barrier, which was based on a design by George Eicher, a Portland, Ore., biologist, was built and tested by Hosey & Associates Engineering Co. in Bellevue, Wash., and Stone & Webster Engineering Corp. in Boston.

The success of this "Eicher screen" notwithstanding, the Elwha project and a nearby larger dam called Glines Canyon are now in jeopardy. Neither the Glines nor the Elwha has fish ladders, and after a seven-year study, the U.S. National Park Service in Washington, D.C., concluded that such ladders could not be installed at the Glines because the dam is so steep. The Park Service and the Fish and Wildlife Service now favor removal of both dams to reestablish the population of chinook salmon that used to spawn far upriver in the Elwha before the dams were built—more than 60 years ago.

Both dams are now up for licensing or relicensing. As part of the application review, the Federal Energy Regulatory Commission is preparing to release a draft environmental impact statement for each of the various options under consideration: removal of both dams, one of the dams, or neither.

Springer, FERC's director of hydropower relicensing, declined to comment on the application beyond noting that the "removal of the dams would be an expensive undertaking, because of the large amount of sediment behind them." He added that it would be important to "lay before the public the costs and impacts of doing that [removing the dams], so that it can weigh those costs against the goal of reestablishing the anadromous runs."

A similar case involves the Edwards Dam on the Kennebec River in Maine, a 3.5-megawatt project whose license expires in 1993. State officials oppose relicensing on the grounds that attempts to build equipment to get fish upstream past the dam have been unsuccessful, and that the dam's reservoir inundates a once-important spawning and nursery area for striped bass, rainbow smelt, and Atlantic and shortnose sturgeons.

To probe further

"Safe Passage for Migrant Fish" was published in the Electric Power Research Institute's monthly publication, *EPRI Journal*, in December 1987. "Tools of the Trade for Hydro Relicensing," July/August 1988, also covered fish protection.

Northwest Energy News, published by the Northwest Power Planning Council in Portland, Ore., has articles outlining the council's view on fish-related issues in almost every issue. Another useful source is *Hydro-Review*, the self-proclaimed "Magazine of the North American Hydroelectric Industry," published bimonthly by HCI Publications, Kansas City, Mo. ◆

Research and reporting assistance was provided by Tony Healy in Sydney, Australia.

January 27, 1947

Keithley's phantom repeater

Applying wartime technology

It has become a cliché that World War II served as a "forcing house" for the electronics industry, advancing within a five-year period the development of radar, computer, and other equipment by several decades. Among the technological developments that came out of that global conflict was one that attracted little notice at the time, but one that has proved extremely valuable to the modern semiconductor industry—the driven-shield technique for making measuring instruments with high-input impedances.

That concept, which was conceived at the Naval Ordnance Laboratory (NOL) in Washington, D.C., was first put to commercial use in Joseph F. Keithley's phantom repeater.

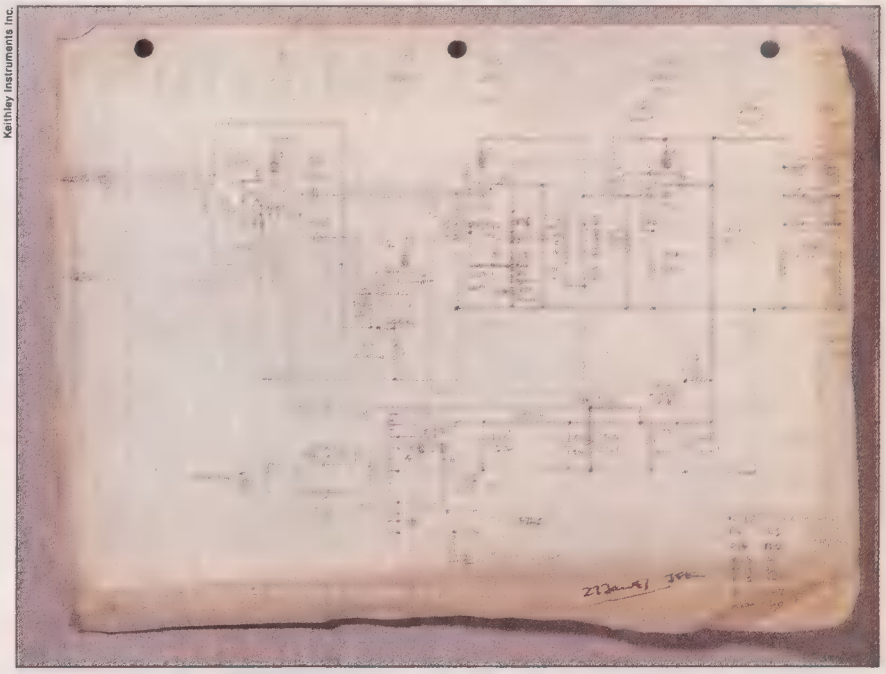
During the war, Keithley was a scientist at the NOL working with extremely small underwater microphones—units with capacitances of only a few picofarads. While he was there, the problem arose of how to get a signal from such minute capacitances down about 30 centimeters of shielded cable to an amplifier.

The solution devised by the NOL was to drive the shield with a cathode follower.

It works like this: because the shield is driven with almost the same instantaneous voltage as the cable's center conductor, the circuit being measured needs to supply only a tiny fraction of the usual charge. The apparent capacitance of the load placed on the circuit is thus greatly reduced. Similarly, only a fraction of the usual current flows through the conducting paths, greatly increasing the apparent load resistance. In short, the driven-shield concept provides extremely high impedance at the ends of the test leads, even when the test leads have substantial shunt capacitance. It can thus make measurements on high-impedance components and circuits without loading them down.

When the war was over, and Keithley began making plans to start his own business, he focused on the driven-shield concept because he felt it would be useful to researchers in many areas of electronics.

IEEE Spectrum *Staff*



Keithley Instruments Inc.

This first complete diagram of the phantom repeater, drawn by Joseph F. Keithley in Keithley Instruments Notebook No. 1 on Jan. 27, 1947, shows how cathode follower V2 is used to drive the shield that completely surrounds the front end. The two-stage feedback-stabilized output amplifier provides user-selectable fixed gains of 1, 10, and 100. The three parallel outputs are at the far right.

At the time, there were only two ways to measure audio-frequency signals—using voltmeters with a diode in the probe or the voltmeter made by Ballantine Laboratories Inc.

The probe voltmeters had adequate input impedance, but they had many drawbacks as well. They were not very sensitive, requiring volt-level signals when there was a need to measure millivolts and microvolts. Also, they provided no clues about the nature of the measured signal.

The Ballantine meter, a feedback-stabilized ac amplifier, overcame most of those problems but introduced one of its own. Its input impedance was only half a megohm, which made it useless for making measurements on high-impedance pentode plate circuits, for example.

Responding to those problems, Keithley designed an instrument that used the driven-shield principle to provide a high-input impedance, a choice of three fixed gains, and three parallel outputs. He based his instrument on the NOL work, but he also took out a license from AT&T Co. so he could use negative feedback to stabilize the gains of the two amplifier stages. The drawing [see photo], from the very first notebook to carry the name Keithley Instruments, is the circuit he developed.

In a recent telephone interview with *IEEE Spectrum*, Keithley said that, to the best of his recollection, there are no differences between this drawing and his first production models. No patent was issued for the phantom repeater because it contained no proprietary circuits and was based on work done at NOL, a U.S. government entity.

He called the instrument a phantom repeater, "phantom" because its impedance of 200 megohms shunted by 6.2 pF was so high it was hardly noticeable, and "repeater" because the output was a faithful reproduction of the input.

Interestingly, the instrument was only a moderate commercial success. Its real significance was to stimulate interest in high-impedance measurements. In particular, it inspired one of Keithley's wartime colleagues to suggest that Keithley Instruments complement the ac instrument with a high-impedance dc voltmeter. That product, which was based on an electrometer tube, really took off and is the basis of the company's success today.

Yet, the phantom repeater lives on. Today, the driven-shield concept is at the heart of most wafer testers in Silicon Valley, including those made by the Systems Division of Keithley Instruments. ✦

0018-9235/90/1200-0071$1.00©1990 IEEE

Putting electronics to work in the 1991 car models

Electronically controlled transmissions, suspensions, and variable-valve timing and lift highlight the global innovations

In a maturing automotive electronics arena, most of the innovations in 1991 models worldwide are variants on basic systems that appeared previously on other models. In the United States, Ford Motor Co. and General Motors Corp., for example, have incorporated electronically controlled automatic transmissions in some new models, but they are similar to systems introduced by Ford in 1989 on some of its light trucks and by Chrysler Corp. in 1990. In another variation, Volvo Car Corp. of Sweden has introduced a version of its Model 960 that incorporates three different driving modes—economy, sport, and winter.

Various versions of electronically controlled suspensions have also been available on some models for several years, and for 1991, General Motors is introducing its own versions. But the ultimate in electronic suspensions, ■ fully active suspension, is now available as an option on the 1991 Infiniti Q45 from Tokyo-based Nissan Motor Co. It is the first time that a fully active suspension has been offered on a production automobile in the United States, although one is also available on 300 1991 Toyota Celicas to be sold in Japan.

Still, ■ totally new category is an electronic variable-valve timing and lift control system on the Acura NSX, a mid-engine sports car from the Acura Automobile Division of American Honda Motor Co., Garden City, Calif.

The quality of cars has been improving steadily for the past few years. In fact, this year, for the first time, a U.S. automobile manufacturer—GM's Cadillac Motor Car division in Detroit, Mich.—won the Malcolm Baldrige National Quality Award for excellence in quality management.

Smoother shifts with electronics

In the never-ending quest for smoother shifting—coupled with ongoing efforts to minimize fuel consumption—electronics is key. On some of its 1990 models, Chrysler introduced to the industry real-time electronic feedback controls for all shifting functions in an automotive transmission. Called Ultradrive, the four-speed automatic transmission earned for its inventors—Maurice B. Leising, Howard L. Benford, and Gerald L. Holbrook—the 1990 Society of Automotive Engineers' Henry Ford II Distinguished Award for Excellence in Automotive Engineering. Ultradrive has one-third fewer parts than typical competitive four-speed units, and reduced Chrysler's tooling costs by more than US $100 million.

At Ford, in Dearborn, Mich., the company introduced its 1991 AXOD-E model transaxle, an updated and upgraded version of its 1990 AXOD model. The AXOD-E has been engineered for optimum fuel economy and performance with consistent shift quality. The transaxle control is integrated into the computerized EEC-IV powertrain control system, which processes various inputs from the engine, transaxle, and other vehicle components to control precisely the operation of the transmission. The system varies line pressure in response to changes in temperature, altitude, and engine torque to provide smooth shifts in most driving conditions.

A fully automatic unit, the AXOD-E has a three-element hydraulic lock-up torque converter. It couples the engine to the planetary gears and overdrive unit with a chain assembly that connects the drive and driven sprockets. Application of the converter clutch is scheduled through electronic controls in the powertrain control system.

Various input sensors provide the powertrain control system with information on engine and transaxle operation [Fig. 1]. The system then processes the data and sends signals to operate output solenoids. These input sensors comprise:

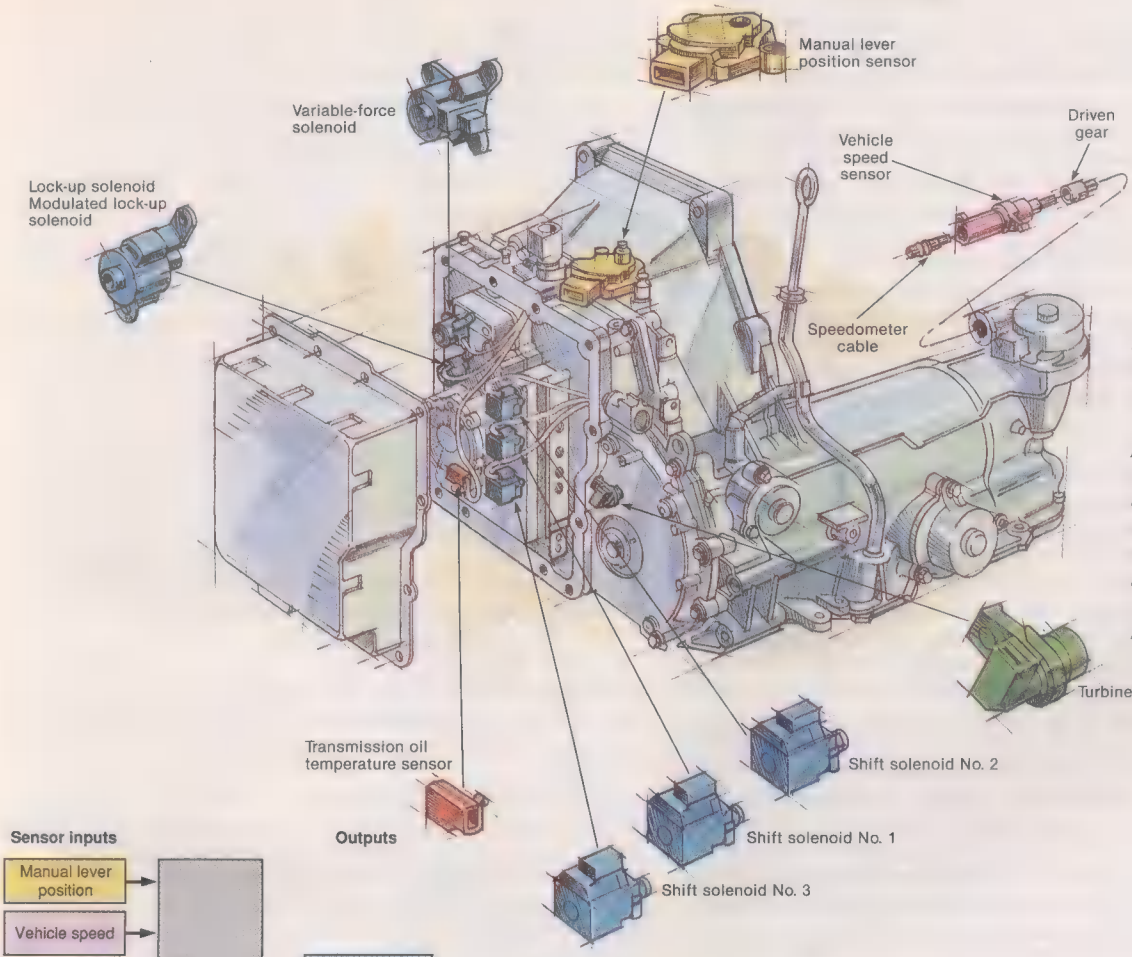
- A sensor that detects whether the shift lever is in park, reverse, neutral, overdrive, drive, or manual low.
- A variable-reluctance pickup that provides an ac signal proportional to the transaxle output shaft revolutions per minute.
- A thermistor that sends a voltage signal proportional to the transaxle oil temperature.
- A variable-reluctance device that generates ■ variable-frequency signal in response to the rotation of an exciter wheel mounted on the transaxle's driven sprocket.
- A potentiometer mounted on the throttle body that feeds the powertrain control system a voltage signal proportional to the opening of the throttle plate.
- A constant-temperature, hot-wire anemometer that measures

Defining terms

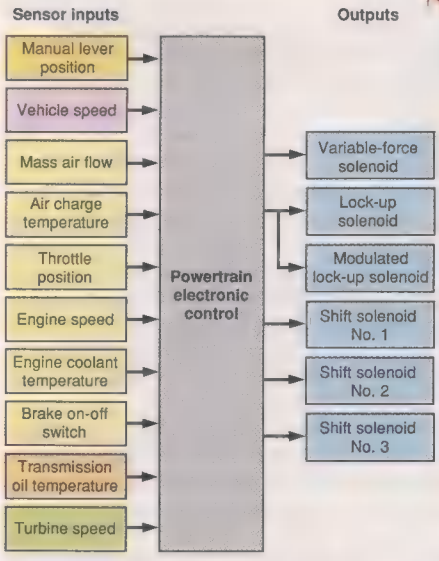
Fully active suspension: an electronic system in which hydraulic or other powered actuators lift or lower the wheels in response to signals from sensors that detect road surface conditions or movements such as roll, dip, yaw, acceleration, and deceleration.
Lock-up torque converter: a hydrodynamic torque converter using ■ clutch to provide ■ direct mechanical drive.
Overdrive transmission: a transmission that provides ■ speed ratio wherein the output speed is greater than the input speed. In the case of an overdrive transaxle, the output speed is modified by the final drive.
Planetary: having or consisting of an epicyclic train of gear wheels.
Rocker arm: ■ center-pivoted lever to push an automotive engine valve down.
Torque converter: ■ hydrodynamic drive that transmits power and has the ability to change torque.
Transaxle: ■ transmission that divides the driving force equally between two shafts or axles in the same line and permits one shaft to revolve faster than the other.
Valve timing: the valve opening and closing points in the operating cycle.

Ronald K. Jurgen Senior Editor

0018-9235/90/1200-0072$1.00©1990 IEEE



[1] Ford Motor Co.'s AXOD-E automatic transaxle is controlled by a powertrain control module. It sends signals, in response to inputs from various sensors, to a series of solenoids that control the shifting of gears.



the rate of mass airflow into the engine.

- A Hall-effect device in the distributor that detects engine revolutions per minute and crankshaft position.
- A switch that, when closed, indicates that the brakes are being applied and, when open, that they are not.

Three shift solenoids provide gear selection by controlling the pressure to the shift valves. Another solenoid controls the lock-up torque converter clutch on the Ford Taurus and Mercury Sable models. It is normally open, but when activated by the powertrain control system, it applies pressure that causes the converter clutch to engage.

On Lincoln Continental models, a modulated solenoid for the lock-up clutch is used. When activated by the powertrain control system, it varies output pressure and controls clutch slip by adjusting its pulse width; the powertrain control system turns on the solenoid at a constant frequency, but the length of time it stays on varies. The wider the pulse, the greater the output pressure the solenoid allows. By varying the solenoid pulse width, the powertrain control system can apply and release the converter clutch and also allow controlled clutch slip.

The electronic pressure-control solenoid combines a variable-force solenoid and a pressure-regulating valve. It produces pressure control that regulates electronically transaxle line pressure and shifting clutch capacity.

General Motors' version of an electronically controlled four-speed automatic transmission is the 4T60-E from the Hydramatic Division in Ypsilanti, Mich. The 4T60-E is available on several 1991 models from the Oldsmobile, Buick, and Cadillac divisions.

The 4T60-E features one-way clutches on all forward speeds for smooth gear changes under all operating conditions. These clutches automatically release one gear as the next one is applied. In a traditional automatic transmission, shifts are handled by friction elements commonly known as bands or clutches. Under ideal circumstances, one friction element releases exactly as the second one is applied, and the transmission shifts smoothly. But after normal wear, temperature changes, and other variations in driving conditions, a band release may occur too late or too soon. If too late, the transmission binds momentarily because it is trying to be in one gear while also trying to shift to another. If too soon, the engine speeds up until the clutch grips. In both cases, the driver is aware of the shift.

These problems are eliminated with one-way mechanical clutches. Four solenoids allow the powertrain control computer to determine the timing of each forward shift. Because the entire powertrain is controlled by a single computer, the transmission, converter clutch, and cruise control can work in harmony. For example, when cruise control is engaged, the transmission

shift pattern can be altered to minimize the hunting between third and fourth gear that may occur on long upgrades.

The computer is programmed to lessen engine power the moment gears are shifted and to gently reapply engine power once the next gear is engaged. The computer accomplishes this by retarding engine timing and cutting fuel flow. The result is barely perceptible gear changes during normal driving. Wear and tear on the drivetrain is also much reduced.

Although only one pair of solenoids controls the four forward speeds in the transmission, that pair can, through the use of binary logic, provide the four gear choices. In Cadillac models, a second pair of solenoids controls a viscous converter clutch that provides a firm link between the engine and drive wheels so that fuel economy is increased during highway driving. One solenoid in the pair applies the converter clutch; the second, called a pulse-width-modulated solenoid, varies the rate at which the converter clutch is applied. When teamed with the viscous damper in the clutch itself, these solenoids make converter clutch operation almost imperceptible to the driver.

The 1991 Volvo 960 has a distinctive electronically controlled four-speed automatic transmission that offers a choice of three driving modes, automatic engine braking on downgrades, and control of the slip time at the moment the gears change—especially useful when driving at high altitudes.

Any one of the driving modes—economy, sport, or winter—is selected by pressing the corresponding button mounted on the panel beside the floor-mounted automatic gear lever. Fuel consumption is the basis for the choice of gear change. All the shift schedules are stored in an electrically programmable ROM. Schedules differ for gear lever positions D, 3, and L, depending on the driving mode selected, so there is a total of nine schedules.

The economy mode, naturally enough, minimizes fuel use. In the sport mode, the driver can accelerate and change gears quickly. A microprocessor controls the gear changes so that engine output is the same before and after a change; promoting both smooth gear shifts and good performance. If the driver accelerates normally, the car responds in the economy mode.

In the winter mode, the gearbox functions essentially as a manual unit, so that a given gear-lever position (PRD3L) engages a particular gear. For example, in the drive (D) position, the car starts in third gear and then changes to fourth. When the gear lever is in position 3, the car starts in second gear. In low (L), it starts in first gear.

On a downgrade, the electronic system in the Volvo 960 registers the car's continued acceleration even after the accelerator pedal is no longer depressed. The gearbox reacts automatically and ensures that the speed remains constant by switching automatically to a lower gear. As soon as the driver depresses the accelerator pedal, the function disengages.

At high altitudes, where the oxygen content of the air is lower than at sea level, the output and torque of the engine also fall off, at times causing a sharp change in gears. A special monitoring function in the Volvo system registers engine output and controls the slip time at the moment the gear changes.

If a fault should arise with the transmission that puts the electronic system out of commission, the driver can still "limp home" through use of two forward gears and reverse.

The best of all suspension worlds

Suspension designers in the past have been forced to compromise between a firm feel at highway speeds but a harsh ride around town, and a soft, luxurious ride but poorer handling qualities. In recent years, though, electronics has let them provide both a firm and a soft ride.

Standard equipment on 1991 Cadillac Fleetwood, Eldorado, and Seville models (and optional on De Villes), a new suspension system called Computer Command Ride (CCR) uses a computer to automatically vary the damping rates of the suspension struts that control the up-and-down movement of the wheels. The system makes the damping softer or firmer, depending on vehicle speed and other driving conditions.

At low speeds, softer damping makes for a smoother ride. At higher speeds, damping becomes firmer for more precise handling. The computer also provides stiffer damping during hard acceleration, braking, and cornering for increased control.

The CCR system uses a computer-controlled damper or strut at each corner of the car. Developed by GM's Delco Products Division, Dayton, Ohio, the three-position (comfort, normal, or firm) damper houses a selector valve, which changes damping rates almost instantly in response to a signal from the computer. The selector valve is driven by a small dc motor inside the strut. By using orifices of different sizes, the selector valve restricts fluid flow through the main valve in the damper.

At speeds up to 40 miles per hour (65 kilometers per hour), the computer will generally select the comfort setting. It provides light damping to reduce the amount of road shock transmitted to the car body. At speeds from 40–60 mi/h (65–95 km/h), the computer selects normal damping for a firmer ride and better control. At speeds above that, the computer selects firm damping—as it also does during heavy acceleration and hard braking—to reduce body pitch and enhance driver control.

All these changes occur without any driver input. In many cases, the driver is not even aware that a change in damping has occurred, because the extra damping essentially matches the increased demands being placed on the suspension.

The Oldsmobile Ninety-Eight Regency Elite for 1991 has a somewhat different version of the CCR system. A switch to the right of the steering column allows the driver to select either normal or firm suspension damping. In response, valves inside all four shock absorbers move to alter both bounce and rebound damping.

The Oldsmobile system also has an automatic function. If the CCR switch is set in the normal position and the driver makes an aggressive cornering, braking, or accelerating maneuver, the computer automatically calls for firm damper settings.

Nissan Motor is offering an optional, fully active suspension on the 1991 Infiniti Q45 for US $4000. An oil pump on the Full-active Suspension System produces hydraulic pressure to continuously negate the external forces—bounce (up-down), pitch (front-back), and roll (left-right)—that work to move the vehicle.

Nissan said that the inspiration for the suspension system came from the cheetah, the fastest animal on earth. The cheetah always keeps its body parallel to the ground, and no vibrations penetrate its body as it expands and contracts its four legs to adapt to the contours of the land. The cheetah has the ability to travel at high speeds while making instantaneous decisions on how to move its legs so as to minimize the impact on its body from the ground and keep its body parallel to the ground.

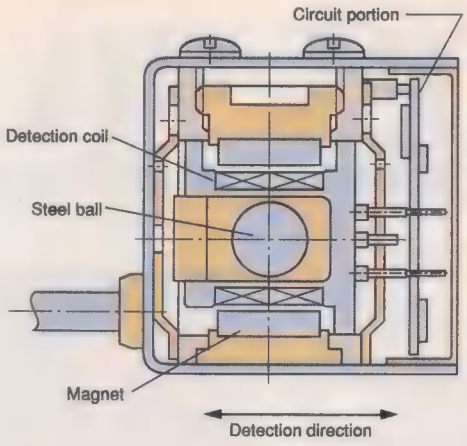
Another of Nissan's inspirations was the skier. As a skier descends a slope, his skis move up and down with the contours of the snow, but there is almost no up-and-down movement of the upper body. This is because the skier is extending and contracting his legs according to those contours.

The Nissan system relies on three vertical gravity sensors [Fig. 2] to detect changes in vehicle bounce acceleration, one fore and one aft G sensor to detect pitch acceleration, and two transverse G sensors to detect lateral acceleration.

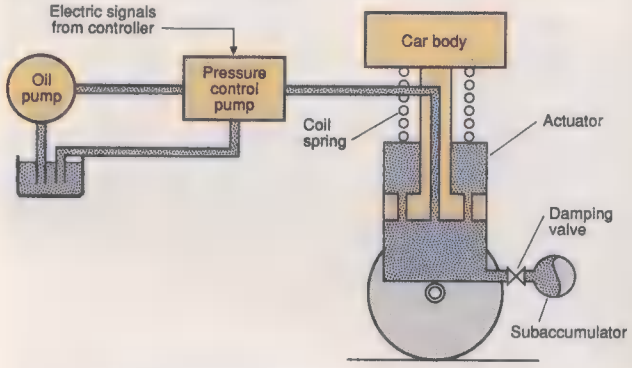
Four additional sensors—rotational, potential-balance register types—detect changes in the vehicle's height by using the angular changes of the suspension arm of each tire. The sensors' outputs go to a pair of 16-bit microprocessors, which signal hydraulic actuators to continuously adjust chassis height and balance at each wheel [Fig. 3].

In operation, the suspension system is lifted and lowered to maintain optimum tire-to-road contact. The actuators extend the wheels downward over dips or undulations to suspend the body in a flat, stable position. Actuator pressure is reduced to control rebound by keeping the body level without imparting an overly soft ride.

In a hard corner, body roll is suppressed by increasing oil pres-



[2] The G sensors used in Nissan Motor Co.'s fully active suspension system are of the ball position-detection type, similar to those used in some instruments. The sensors detect changes in the magnetic field caused by the change in position of a steel ball as a result of acceleration.



[3] The actuator at each wheel in Nissan Motor Co.'s fully active suspension system includes an auxiliary coil spring to reduce the amount of hydraulic pressure needed to suppress changes in vehicle body position. The subaccumulator and damping valve at the bottom of the hydraulic power cylinder absorb and damp the high-frequency vibration of the spring.

sure at the outer wheels while reducing it at the inner wheels. This greatly enhances handling and stability. By the same technique, front-to-rear body movements are balanced to eliminate most acceleration lift and brake dive.

Power through variable valve timing

Another compromise that has confronted designers is adjusting engine design to allow for low-end torque and high-end power. To eliminate the need for a tradeoff, engineers from American Honda's Acura Automobile Division have designed a variable-valve timing and lift electronic control system (VTEC). It is featured on the new mid-engine NSX sports car.

The heart of VTEC is a unique camshaft and rocker arm system. VTEC is installed on both the intake and exhaust sides of the engine and works similarly in both places.

On the intake side, each cylinder's set of two intake valves has three corresponding lobes on the camshaft. Each of the two outboard lobes has a profile suited for low engine speed, with each having a different lift profile to induce a swirl for more complete combustion. One has a total lift of 8.7 millimeters; the other, 8.3 mm. The lobes act on rocker arms, which, in turn, act on the intake valves in a conventional manner. The third, or center cam lobe, has a dramatically different profile designed for longer duration and a higher lift of 10.2 mm. This optimizes breathing and horsepower production at high engine speeds.

The high-lift lobe acts on the center rocker arm, which then acts on a lost-motion spring. The spring's function is to reduce arm play while VTEC is disengaged.

Two pistons and a stopper pin are installed at right angles to the rocker arms. Under high-load or high-speed operation, the VTEC computer sends a signal to a spool valve, which delivers engine oil to the pistons in the rocker arms. Oil pressure causes the pistons to slide inward, locking all three rocker arms together. It takes an oil pressure of 4.5 kilograms per square centimeter to overcome the spring pressure and engage VTEC.

Once locked together, the rocker arms are forced into following the profile of the high-lift center cam lobe. At this point, the intake valves have the higher 10.2-mm lift and longer duration, improving engine breathing and noticeably increasing power. The crossover from low to high lift occurs in 0.1 second and is virtually transparent to the driver.

VTEC uses a dedicated central processing unit that monitors a number of engine parameters and activates the system only when certain thresholds are reached. It engages at 5800–6000 revolutions per minute, depending on conditions, and never under a no-load situation.

As installed and calibrated in the NSX engine, VTEC adds 20 horsepower and also provides more torque and a broader torque curve. VTEC is covered by numerous patents and is exclusive to Honda.

A quality award to Cadillac

Not too many years ago, U.S.-produced automobiles were considered far inferior in quality to those produced in Japan and Europe. But U.S. carmakers have been steadily improving quality and, as proof of their progress, one company—GM's Cadillac Motor Car Division—has received the prestigious 1990 Malcolm Baldrige National Quality Award for excellence in quality management. It is the first time that a U.S. carmaker has won that recognition.

Firms applying for the award must undergo a rigorous evaluation by an independent board of examiners composed of experts in quality from both the private and public sectors. The examination includes on-site visits for those passing the initial screening.

And what we had to omit

Because of space limitations, many other electronics applications in 1991 models could not be covered. For example, GM introduced the ABS VI antilock braking system on some of its models. It uses advanced electronics to replace mechanical complexity and keep down costs. The Lincoln Town Car now has traction control, previously available on some cars from other companies.

To probe further

For more information on the Chrysler Ultradrive transmission, a paper is available from the Society of Automotive Engineers (SAE) . Written by the three inventors of Ultradrive, "The All-Adaptive Controls for the Chrysler Ultradrive Transaxle,"—SAE paper No. 890529—is available from SAE, 400 Commonwealth Dr., Warrendale, Pa. 15096-0001; 412-776-4841.

For basic information on suspension systems, the book *Car Suspension and Handling*, Second Edition, by Donald Bastow, Pentech Press, London, gives design features of all basic suspension types, including active suspensions. The book is available from SAE at the above address.

The 1991 SAE International Congress and Exposition will be held February 25–March 1 at Cobo Center, Detroit, Mich. Many of the technical sessions will deal with automotive electronics. For further information and a copy of the final meeting program, contact SAE's Communications Division in Warrendale, Pa.; 412-772-7131.

AWARDS/90

IEEE service awards and prize papers

Robert M. Saunders (LF) received the Haraden Pratt Award "for distinguished service in extending IEEE leadership in the educational and professional communities, and as a founder and early chairman of the American Association of Engineering Societies."

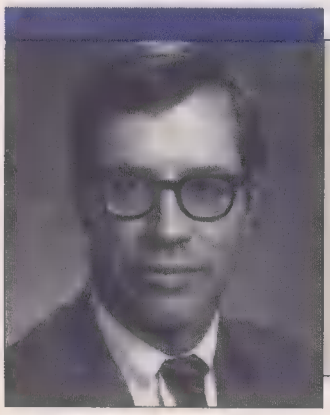
Saunders is professor of electrical engineering emeritus at the University of California at Irvine. He has been at Irvine since 1964 and before that had spent 18 years on the university's Berkeley campus. He organized the School of Engineering at Irvine. He received the BSEE and M.S. degrees from the University of Minnesota. Saunders' many activities in the IEEE over the years include serving as President in 1977, on the Board of Directors from 1973 to 1980, and as Vice President–Regional Affairs in 1976.

Harold Chestnut (LF) received the Richard M. Emberson Award "for leadership and dedication to the Institute's technical growth and service worldwide, and for the development of systems engineering concepts."

Chestnut is president of SWIIS Foundation Inc., in Schenectady, N.Y. He earned BSEE and M.S. degrees from the Massachusetts Institute of Technology in Cambridge. His entire career, prior to retirement in 1983, was spent in various positions with the General Electric Co., including serving as manager of the systems engineering and analysis branch in the Advanced Technology Laboratory. Among his projects were the Apollo Mission reliability systems. Chestnut's activities in the IEEE have included holding the offices of President, Treasurer, Vice President–Technical Activities, and Vice President–Regional Activities.

Allen C. Newell (SM) received the W.R.G. Baker Prize Award for his paper, "Error Analysis Techniques for Planar Near-Field Measurements," published in the June 1988 issue of *IEEE Transactions on Antennas and Propagation*.

Newell is a group leader, Antenna Metrology Group, Electromagnetic Fields Division, of the National Institute of Standards and Technology in Boulder, Colo. He joined the organization in 1960 and, since 1962, has been involved in a variety of microwave and millimeter-wave measurement problems. He is a recognized expert in the area of near-field antenna measurements and has received the Bronze and Silver Medal Awards from the Department of Commerce for his work. His IEEE activities include service on the Administrative Committee and the Antenna Standards Committee of the Antennas and Propagation Society.



G. David Forney Jr. (F) received the Donald G. Fink Prize Award for his two papers, "Coset Codes—Part I: Introduction and Geometrical Classification," and "Coset Codes—Part II: Binary Lattices and Related Codes." Both papers were published in the September 1988 issue of the *IEEE Transactions on Information Theory*.

Forney received his BSEE degree from Princeton University in New Jersey and M.S. and Sc.D. degrees in electrical engineering from the Massachusetts Institute of Technology in Cambridge. He is vice president of Codex Corp., Mansfield, Mass. Forney was editor of the *IEEE Transactions on Information Theory* during 1970–73. He has been a member of the board of governors of the Information Theory Group/Society and is its President-Elect for 1992.

Roberto G. Rojas (M) received the Browder J. Thompson Memorial Prize Award for his paper, "Wiener-Hopf Analysis of the EM Diffraction by an Impedance Discontinuity in a Planar Surface and by an Impedance Half-Plane," published in the January 1988 issue of the *IEEE Transactions on Antennas and Propagation*.

Rojas is senior research associate at the Ohio State University Electroscience Laboratory, where he has worked since 1979. His current research interests have established new boundary conditions to represent such surfaces; these simplify the analysis of electromagnetic scattering by bodies with nonconducting surfaces. He is also involved in upgrading of computer codes and scattering of EM fields by aircraft and other objects. He is a member of the IEEE Antennas and Propagation Society and the Microwave Theory and Techniques Society.

IEEE Engineering Leadership, Corporate Innovation Awards

Irwin Dorros (F) and **Edson Fregni** (M) received the IEEE Engineering Leadership Recognitions, Dorros for "outstanding leadership in the creation and management of Bell Communications Research Inc.," and Fregni for "pioneering in the computer industry in Brazil, and for major contributions to his country's technological development."

Dorros is executive vice president–technical services of Bell Communications Research (Bellcore), where he is responsible for all technical activities, including applied research, systems engineering, and software development for the seven client/owners of Bellcore. He provided the key engineering leadership for the creation of Bellcore and negotiated the transfer of 3000 scientists and engineers, and of needed laboratory facilities, from Bell Labs into Bellcore to implement the program. His leadership has greatly influenced North American ISDN standards and implementation, massive deployment of optical-fiber facilities, and "intelligent network" architecture for new services. Dorros holds B.S. and M.S. degrees in electrical engineering from the Massachusetts Institute of Technology in Cambridge and an Eng. Sc.D. from Columbia University in New York City.

Fregni is president of Spectrum Ltd., São Paulo, Brazil. He cofounded Scopus Tecnologia, also in São Paulo, one of his country's first companies in the field of information technology. He also played a prominent role in the formulation of the Brazilian Informatics Policy, which aims to develop an independent Brazilian capability in digital electronics, software, and related fields. Since 1972, Fregni has been an assistant professor at the Escola Politécnica da Universidade de São Paulo, from which he received a bachelor's degree in electronics engineering and a master's in engineering.

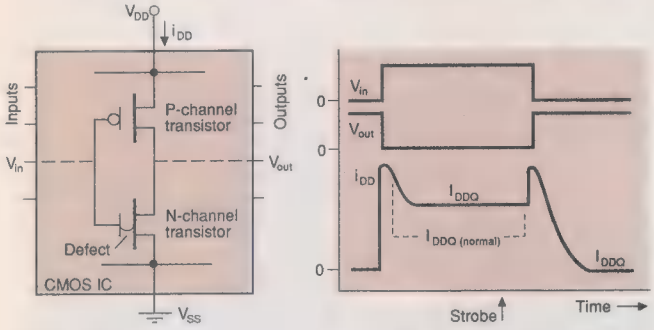
IBM Corp. has won the IEEE Corporate Innovation Recognition "for the development of the multilayer ceramic thermal conduction module for high performance computers."

Prior to the development of the multilayer ceramic thermal conduction module for application in IBM computers in the early 1980s, large computer systems were difficult to cool because of the high density of circuits and chips they contained. The density of circuits achieved by IBM with the thermal module was three orders of magnitude higher than that achievable by the state of the art. IBM's development contributed significantly to the growth of the computer industry.

The faults in CMOS IC fault testing

The most popular method of testing CMOS ICs for faults may itself be at fault. According to Sandia National Laboratory researcher Jerry Soden, this method focuses on "stuck-at" faults while neglecting the primary causes of CMOS IC failure.

In his 15 years at the laboratory, Soden said he has seen only two instances of defects that could accurately be described as stuck-at faults, in which a node is stuck in a logic state of 0 or 1 because of a short to ground or power supply voltage.



The power supply current of a CMOS IC during its quiescent (nonswitching) state, I_{DDQ}, rises when a defect is present. The response of the above circuit's supply current, i_{DD}, to an input voltage representing logic state 1 is plotted at lower right.

Sandia, Albuquerque, N.M., is educating industry about a method that can detect not only stuck-at faults, but defects such as gate oxide shorts, bridges, and parasitic transistor leakage. Called I_{DDQ} testing, the method measures the power supply current during the circuit's quiescent (nonswitching) state. Sandia and Phillips NV of the Netherlands have worked with the I_{DDQ} test technique for high-reliability ICs since the 1970s.

I_{DDQ} indicates a defect directly, whereas functional tests generate a series of logic patterns at the IC input and then check for correct logic output. Many manufacturing defects do not affect circuit function and logic state until the chip has operated for a time, so logic response testing may allow faults to slip through.

Logic response testing is essentially design verification, said Soden: "It shows that a circuit will do the job it was designed to do, but it cannot be relied upon to find all errors in improperly fabricated integrated circuits."

The method exploits the low current of less than 10 nanoamperes typical for CMOS during the quiescent state. Its low power consumption has made CMOS the dominant IC technology. Defects in the circuit usually raise the quiescent current abnormally high for certain input logic patterns, but do not necessarily register as a change in the output's logic state.

A prime advantage of the I_{DDQ} method, according to Soden, is that "you don't have to propagate the logic signals to an output pin to observe abnormalities." Therefore, the method can more easily provide 100 percent coverage of transistor nodes for stuck-at fault testing. Test patterns that produce both logic states at every node assure that quiescent current will increase when there is a stuck-at-one or stuck-at-zero fault anywhere in the circuit.

But Soden said Sandia is promoting the method for detecting other kinds of faults. "The stuck-at approach is not the best for detecting defects," he told *IEEE Spectrum*. "It is an abstraction created for finding faults because it was suited to computer analysis."

To detect gate oxide shorts, punchthrough, parasitic transistor leakage, leaky pn junctions, and transmission gate open circuits, I_{DDQ} tests need only put all transistor nodes in the 1 and 0 states. To uncover bridging defects, the I_{DDQ} test also must be able to force adjacent nodes to opposite logic states.

Warren Debany, group leader of microcircuit simulation and testability at Rome Air Development Center, Griffiss Air Force Base, N.Y., said although some in industry have been using the method in abbreviated form, only recently has there been an upsurge in interest in it for more extensive testing. Mark Levi, a physicist with Rome Air Development Center, Rome, N.Y., was the first in 1981 to formally propose using the method for CMOS defects, particularly stuck-at faults and bridging defects.

One obstacle to its spread has been the prevalence of automatic test generation software geared to the stuck-at-fault test methods. AT&T Co., which operates Sandia, recently introduced a sequential circuit test generator called Gentest that is particularly suited to I_{DDQ} testing.

About nine months ago, Rome added a procedure to MIL-STD-883 that allows the use of I_{DDQ} techniques in the qualified manufacturers list (QML) program, which certifies IC suppliers for the military.

"There may be one or two stuck-at-one or stuck-at-zero faults that the I_{DDQ} method misses," he said, "but we believe the benefits of detecting other faults, like stuck-opens and bridging defects, outweigh that potential deficiency."

Sandia has been giving technical seminars on CMOS IC quality improvement that include I_{DDQ} testing and presented two papers on the technique with the University of New Mexico at the 1990 International Test Conference.

Bad machine dreams

The more heavily companies rely on computers, the more often power outages show up in chief executives' nightmares. The hazards of power loss became readily apparent on Monday, Aug. 13, when a fire in an electric substation caused a large outage over 70 blocks on Wall Street.

Because of the failure, the New York Mercantile Exchange, the Commodity Exchange, the New York Futures Exchange, and the American Exchange were forced to curtail trading for part of a day—in some cases two days. More than 100 financial institutions were hurt to some degree. The New York Stock Exchange had an auxiliary power supply so its operations were unaffected, but back-up supplies at Citibank, the Federal Reserve Bank of New York, and others broke down, often because they were too small to handle large loads for extended periods. Most power was restored by the end Monday, but some sites were still without power as late as Sunday.

The Sept. 10, 1990, issue of *Informationweek* reported that Citibank may be subject to penalties of US $100 million for missing payment deadlines as a result of the blackout, but Citibank denies it. Its six back-up generators took 15 minutes to kick in, and a redundant computer for the automatic teller machine (ATM) system lost power. When one generator failed after operating for two days, the others could not carry the load, and the entire site lost power. The company tried to switch operations to another site in Weehawken, N.J., but a communications failure stalled that solution, causing ATM accounts to fall 24 hours behind.

By contrast, Bankers Trust Co., a merchant bank, was unaffected in its operations despite losing external power for six hours. Uninterruptible power supplies (UPSs) and batteries kept its data center and trading floors operating during the two minutes it took six backup turbine generators to start up and begin supplying power to the entire site. Alan Freedman, Bankers' vice president of technology strategic planning, attributes the smooth recovery partly to an active maintenance program for its generators and batteries and partly to annual tests in which the company actually "pulls the plug."

Freedman said the company did not even have to invoke its disaster recovery program, which is intended primarily for internal threats, like an explosion or toxic release in the data center. A Bankers Trust data center in New Jersey would take over operations for New York (and vice versa) in the event of such a disaster. "We spend millions of dollars every year to make sure our recovery program works," said Freedman.

Other companies rely on vendors such as Comdisco Disaster Recovery Services, North Bergen, N.J., IBM Corp.'s Business Recovery Services, and SunGard Services, Wayne, Pa., to provide back-up computer operations, complete with terminals, phone lines, and desks for use by the clients' employees. Subscriber monthly fees range from US $1000 up to US $100 000.

Coordinator: Karen Fitzgerald
Consultant: Robert Thomas, Rome Air Development Center

Hug-me-tight computers

It's hard keeping track these days of all the laptop and notebook computers being introduced into what is regarded as the fastest-growing segment of the computer market. Several recently introduced products feature plenty of computing power and light weight.

A notebook computer from Texas Instruments Inc. weighs in complete with nickel-cadmium battery at just 5.7 pounds (2.6 kilograms), yet has the power and performance of 386SX desktops, thanks to its 20-megahertz 386SX processor. The TravelMate 3000 is equipped with a supertwist liquid-crystal, edge-lit black-on-white VGA display with a 10-inch (25-centimeter) diagonal, as well as a 1.44-megabyte, 3.5-inch diskette drive and ■ 20- or 40-Mbyte hard-disk drive. The standard 2 Mbytes of memory expands to 6 Mbytes.

Texas Instruments Inc.

All of this fits in ■ slender 8.5-by-11-in. (22-by-28-cm) box that is only 1.8 in. (4.6 cm) high when closed. Suggested list price of the TravelMate 3000 is US $5499 with the 20-Mbyte drive, US $500 more with the 40-Mbyte drive.

Another notebook computer with the power of a desktop is Compaq Computer Corp.'s 7.5-lb (3.4-kg) unit, which also relies on a 20-MHz 386SX microprocessor. The LTE 3286s/20 from the Houston, Texas–based company has two models and includes cache memory, an edge-lit VGA display, and 2.5-in. hard-disk and 3.5-in., 1.44-Mbyte diskette drives. The hard drive on the US $6499 Model 30 stores 30 Mbytes, and the one on the US $6999 Model 60 holds 60 Mbytes. Also available is a US $1499 expansion unit that provides full 386SX desktop capabilities, what with its 14-in. VGA color monitor and full-size, enhanced keyboard.

ZEOS International Ltd., St. Paul, Minn., has an under-7-lb (about 3-kg) machine built around an Intel 80286 processor. It includes a 1-Mbyte memory, back-lit VGA display, 20-Mbyte hard-disk drive, and 1.44-Mbyte floppy. Price is US $1995. Optional items include a 2400-bit-per-second Class 5 modem and up to 5 Mbytes of memory.

Those really pressed for computer power on those long transcontinental flights might look out for Toshiba Corp.'s SPARC LT, AS1000/ L10. Its processing speed is 13.2 million instructions per second. According to the company, it is the world's first RISC-based laptop engineering workstation (RISC stands for reduced-instruction-set computer) and utilizes the Sparc architecture developed by Sun Microsystems Inc.

Announced last spring in Tokyo, the 17.7-lb (8-kg) workstation is still sold only in Japan. It has a back-lit, active-matrix, monochrome liquid-crystal display, not to mention 8 Mbytes of memory, a 64K-byte cache, a 3.5-in. diskette drive, and a 180-Mbyte hard-disk drive. Its price is 1 980 000 yen (about US $15 000).

At Texas Instruments Inc., contact Information Technology Group, Box 202230, ITG-065, Austin, Texas 78720-2230; 800-527-3500, or circle 60.

For information on Compaq Computer Corp.'s unit, contact the company's dealers, or circle 61.

At ZEOS International Ltd., contact the Sales Department at 800-423-5891 (612-633-6131 outside North America), or circle 62.

For information from Toshiba Corp., contact Public Communications Office, Toshiba Corp., 1-1-1 Shibaura, Minato-ku, Tokyo 105, Japan; 03-457-2104; fax, 03-456-4776; or circle 63.

MACHINE VISION

VMEbus system sees

Claims of "first ever" come hot and heavy in the electronics field. But a machine vision system for VMEbus computers introduced by Cognex Corp., Needham, Mass., could be more than just another pretty claim.

According to the company, the Cognex 4000 Series machine vision system is the first to combine real-time *image processing* and high-level *image analysis* capabilities. The two-board system plugs directly into a VME backplane for solving industrial gauging, guidance, inspection, and identification problems.

Until now, VME computer users with complex machine vision applications requiring both image analysis and image processing could face a costly integration effort. This involved a variety of image processing, central processing unit, memory, input/output, and special-purpose boards, and the writing of low-level image analysis software for such chores as locating objects or detecting defects.

This system combines a vision processor board based on an MC68030 microprocessor with a frame grabber/communications board equipped with an image digitizer and red-green-blue display controller. It also includes a library of vision software tools and a pair of custom vision chips that perform image analysis and image-processing functions.

Because the vision processor board is compatible with other VME devices, developers can use third-party or custom VME image digitizers to support line-scan camera input, slow-scan video, or other nonstandard video formats. The Cognex 4000 Series will be available in the second quarter of 1991 with ■ price range of US $10 000–$30 000, depending on configuration and quantity. *Contact: Cognex Corp., 15 Crawford St., Needham, Mass. 02194; 617-449-6030; or circle 64.*

COMPUTER AIDED DESIGN

Conference call looks at CAD

Computer-aided design (CAD) conferencing is a new technique from Intergraph Corp. that allows the simultaneous viewing of color or monochrome computer graphics images on the company's workstations at as many as eight sites. An accompanying voice connection lets conferees discuss the on-screen images.

Users may select the most current graphics information and then interactively discuss problems, questions, and changes together, points out company president Eliott James. "Without leaving their offices, engineering and management teams around the globe can work together on projects in real time."

The US $10 995 DataBeam CAD Conferencing module includes software, developed by DataBeam Corp., Lexington, Ky., that manages the interactive communication between workstations, ■ telecommunications interface card, and ■ tablet and stylus for making written notes.

During a conference, participants can redline drawings and engineering-change orders. They can also sign off on a project by putting their signature on the displayed image. *Contact Intergraph Corp., 1 Madison Industrial Park, Huntsville, Ala. 35807; 800-826-3515, or circle 66.*

TOY

Play bridge with a laptop

Now here's ■ new laptop that's not a computer but a machine that plays bridge. Saitek Industries Ltd. said the 128K-byte program in its 5-pound (2.3-kilogram) Pro Bridge 500 is good enough to challenge serious club players, while also storing coaching features for beginners.

The laptop can play as a partner or an opponent with other players, or against itself in an autoplay mode. It plays both rubber and duplicate bridge and can choose from five bidding systems—Acol, American 5-card major, French 5-card major, American Standard, and Precision Club—with 11 bidding conventions. The coaching feature offers hints, suggests cards to play, and allows the takeback of a bid or card.

Opened for play, the unit relies on a panel with four small liquid-crystal display

(Continued on p. 80)

(Continued from p. 79)
screens: one 16-character screen holds two player positions and menu options. Screens at each side of this central screen hold the two other player positions. A fourth screen keeps score.

When not in use, the display panel folds flat and snaps shut over the unit's custom keyboard to measure 9 by 9 by 1.5 inches


Saitek Industries Ltd.

(about 23 by 23 by 4 centimeters). The game works off ■ AA batteries or a voltage adapter and carries ■ suggested retail price of US $399. *Contact Saitek Industries Ltd., 2301 W. 205th St., Suite 108, Torrance, Calif. 90501; 213-212-5412 to find the dealer nearest you.*

SCIENCE

A magazine for amateur scientists

Engineers who fancy themselves amateur scientists may want to look at a new magazine for such dabblers, *Science Probe!* This emphatically named publication promises to cover all areas of science, from astronomy to zoology, bringing together a range of do-it-yourself projects, feature stories, and reports on the achievements of amateurs. The editor, Forest M. Mims, III, is ■ noted science writer with some 60 books and hundreds of articles to his credit. He also styles himself as an active amateur scientist.

Mims' magazine is published quarterly. Introductory subscription price for the first four issues is US $9.95; the cover price per issue is US $3.50. *Contact: Science Probe!, 500-B Bi-County Blvd., Farmingdale, N.Y. 11735; 516-293-0467.*

EDUCATION

Touchy, feely science center

One of the latest Silicon Valley startups is ■ science exhibition center that promises visitors opportunities to hold and explore some of the world's newest technologies. Named, said ■ press release, after the birthplace of many successful high-tech companies, The Garage "goes beyond explaining fundamental principles to give visitors the opportunity to interact with and understand everyday applications of advanced technologies."

Six areas of technology are covered—microelectronics, robotics, space, materials, high-tech bikes, and biotechnology. The Garage, which opened its doors in early November, is part of the Technology Center of Silicon Valley, an organization that fights scientific illiteracy by presenting technology-oriented programs in the hope of inspiring young people to pursue scientific careers. The Garage, open Tuesday through Sunday, is in downtown San Jose, Calif., at 145 West San Carlos. *For ticket information, call 408-247-SHOW, or 415-392-SHOW.*

Modeling radiation in space

The Space Radiation program can help those developing space systems by modeling the effects of ionizing radiation in space on digital electronics and astronauts. Operating on IBM PCs and compatibles, the program can make rapid estimates of single-event error rates, radiation doses, and doses equivalent in any orbit. An 80x87 math coprocessor is strongly recommended.

Space Radiation is based on computer codes developed over the past two decades by the National Aeronautics and Space Administration and the Naval Research Laboratory. Included are the Creme (Cosmic Ray Effects on Microelectronics), cosmic-ray, AP-8 trapped-proton, and Allmag magnetic-field models, and Invar—all considered by Severn Communications as the best available models for radiation effects analysis. *Contact: Jo Ann Letaw, Severn Communications Corp. 223 Benfield Park Dr., Millersville, Md. 21108; 301-987-5236; fax, 301-987-3113; or circle 65.*

Unix catalog

A reference guide to binary-compatible Unix hardware and software is available from the 88open Consortium Ltd., San Jose, Calif., an organization of software and systems suppliers supporting Motorola's 88000 family of reduced-instruction-set (RISC) processors. The guide covers more than 45 hardware systems from six manufacturers that have been tested to meet the 88open standards for Unix System V Release 4 portability. The listings provide product release numbers, as well as levels and options of compliance with the standards.

More than 300 application software packages are also listed, divided into categories of certified, in progress of certification, or promised. Each software package is available in "shrinkwrapped" form. Price is US $4.25 for copies going to consortium members, US $8 for nonmembers. *Contact: 88open Consortium Ltd., San Jose, Calif., at 408-436-6600, or circle 67.*

Coordinator: Alfred Rosenblatt

Organizations seeking engineers and scientists describe their various openings in the following advertising section

In order to conform to the Age Discrimination in Employment Act and to discourage age discrimination, IEEE may reject any advertisement containing any of these phrases or similar ones, "recent college grads," "1-4 years maximum experience," "up to 5 years experience," or "10 years maximum experience." IEEE reserves the right to append to any advertisement, without specific notice to the advertiser, "Experience ranges are suggested minimum requirements, not maximums." IEEE assumes that, since advertisers have been notified of this policy in advance, they agree that any experience requirements, whether stated as ranges or otherwise, will be construed by the reader as minimum requirements only. While IEEE does not ban the use of the term "entry level," its use is discouraged since, to some, it connotes an age rather than an experience designation. IEEE accepts employment advertising to apprise its members of opportunities. Interested parties should be aware that the political and humanistic values of certain advertisers may differ from their own. IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

To place an advertisement in *Spectrum*'s Employment Opportunities section, contact the nearest *Spectrum* sales office

New York	Boston	Philadelphia	Chicago	San Francisco	Los Angeles	Atlanta	Dallas
212-705-7760	508-896-5930	215-368-8232	708-446-1444	415-541-0377	213-649-3800	404-256-3800	214-991-8799

For production/mechanical information contact Wendy I. Goldstein Advertising Production Manager, 212-705-7579

IEEE Spectrum Advertising Dept., 345 E. 47th St., New York, N.Y. 10017

CALENDAR

(Continued from p. 28F)

KWD 217, Box 8, Schenectady, N.Y. 12345; 518-387-5096.

JULY

28th IEEE Nuclear and Space Radiation Effects Conference (IEEE Nuclear and Plasma Sciences Society); July 15-19; Town and Country Hotel, San Diego, Calif; James R. Schwank, Sandia National Laboratories, Division 2144, Box 5800, Albuquerque, N.M. 87185; 505-846-8485.

AUGUST

International Symposium on Electromagnetic Compatibility-EMC '91 (EMC et al.); Aug. 13-15; Hyatt Cherry Hill, Cherry Hill, N.J.; Henry W. Ott, 45 Baker Rd., Livingston, N.J. 07039; 201-386-6660.

SEPTEMBER

Bipolar Circuits and Technology Meeting (ED); Sept. 9-10; Minneapolis Marriott Hotel, Minneapolis, Minn.; John Shier, 2401 E. 86th St., Bloomington, Minn. 55425; 612-851-5228.

Petroleum and Chemical Industry Technical Conference (IA); Sept. 9-11; Royal York, Toronto; Barry Wiseman, Reliance Electric Co., 5220 Creekbank Rd., Mississauga, Ont., Canada L3W 1X1; 416-625-8112.

Third International Conference on Microstructures in Biological Research (ED); Sept. 9-12; Martin Peckerar, 202-767-3150.

Seventh Multidimensional Signal Processing Workshop (SP); Sept. 23-25; Whiteface Inn, Lake Placid, N.Y.; John Woods, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, N.Y. 12181; 518-276-6079.

18th International Conference on Computers in Cardiology (COMP et al.); Sept. 23-26; Venice, Italy; Corso Stati Uniti 4, 35020 Padova, Italy; (39+49) 829 5702.

International Symposium on Gallium Arsenide and Related Compounds (ED); Sept. 23-26; Seattle, Wash.; L. Ralph Dawson, 505-846-3451.

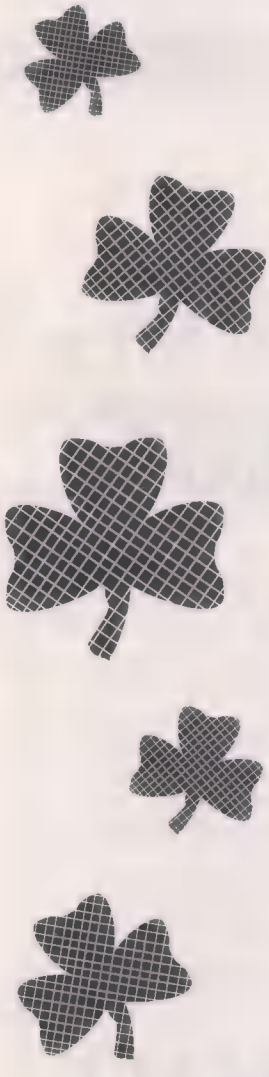
13th Annual Electrical Overstress/Electrostatic Discharge Symposium (EOS/ESD); Sept. 24-26; Riviera Hotel, Las Vegas, Nev.; Terry Welsher, AT&T Bell Laboratories, 600 Mountain Ave., Rm. 3B-321, Murray Hill, N.J. 07974; 201-582-5279; fax, 201-582-5661.

OCTOBER

Fourth International Conference on Amorphous and Crystalline Silicon Carbide and Other IV-IV Materials (ED); Oct. 10-11; Santa Clara University, Santa Clara, Calif.; Cary Yang, 408-554-6814.

International Display Research Conference (ED); Oct. 15-17; Hyatt Islandia Hotel, San Diego, Calif.; Andras Lakatos, 716-422-9700.

Help Us Discover Silicon In Ireland.



Intel Corporation, developer of the world's most advanced microelectronic devices, will be constructing a new state-of-the-art wafer fabrication facility in Leixlip, County Kildare, near Dublin. This new facility will be a Class 1 clean room dedicated to making submicron CMOS logic components.

Are you interested in a career with Intel in Ireland? If so, we would like to talk with you if you have at least three years' experience in one of the following areas. Successful candidates will spend up to nine months in the United States learning Intel's advanced processes and techniques before final assignment in Ireland. All positions require a related technical degree and permanent relocation to Ireland.

CMOS Process Engineering Managers
Senior CMOS Process Engineers
Senior Fab Equipment Engineers
Fab Production Managers
Process Automation Manager
Equipment Maintenance Engineers
Fab Facilities Engineers
CMOS Process Engineers
Yield Analysis Engineers
Fab Industrial Engineers
Fab Production Supervisors
Fab Process Technicians
Equipment Maintenance Technicians

If you'd like to help us make our Leixlip facility the most advanced of its kind in the world, please send or fax your resume to: **Mike Foster, Intel Corporation, Fab 10-0 Dept. MF789, 4100 Sara Road, Rio Rancho, New Mexico 87124, FAX (505) 893-1049.** Intel is an equal opportunity employer.

Intel. A Great Place to Work.

intel®

DEPARTMENT OF THE ARMY JOB VACANCY

ELECTRONICS ENGINEER

The U.S. Army Research Office (ARO), located in Research Triangle Park, North Carolina, is seeking a highly qualified Electronics Engineer to serve as Associate Director of the Electronics Division. This is a Civil Service position at the GS-15 grade level with a salary range of $59,216-$76,982 per annum.

The incumbent will share with the Director the responsibility for directing a broad program of research in the field of electronics including monitoring progress of Division activities towards program goals, proposing resource distribution, representing the Electronics Division at briefings and seminars to insure the effective interchange of scientific knowledge, participating in studies and committees assessing technical areas of importance to ARO and integrating knowledge into the formulation of program plans and objectives. Incumbent will also act as Program Manager for an external contract research program in one or more electronics subfields: micro-electronics; physical electronics and opto-electronics; circuits and signal processing; and antennas and electromagnetic detection. The incumbent will identify new research opportunities, communicate ARO interests to the scientific community, evaluate and select research proposals for funding, manage available resources, and communicate research results to appropriate Army activities.

In addition to the basic requirement of a bachelor's degree in engineering, applicants must have one year of specialized experience in electronics engineering equivalent to the next lower grade in the Federal Service and a background in fundamental research. Applicants should possess (1) Ability to plan, direct and guide a research program in electronics engineering; (2) Ability to evaluate research proposals for technical merit; (3) Advanced knowledge of one or more subfields of electronics engineering and evidence that technical competence has been maintained; (4) Ability to interact effectively with other scientists, professional groups and management officials; and (5) Ability to review and evaluate program implementation and results.

Applicants should submit a Standard Form 171, Application for Federal Employment (available at Federal Job Information Centers and Federal Personnel Offices) and a supplemental statement which addresses each qualification listed above to: U.S. Army Research Office, ATTN: SLCIS-CP-AR, P.O. Box 12211, Research Triangle Park, NC 27709-2211. For further information, call (919) 549-0641, extension 212. Applications must be received by December 31, 1990.

AN EQUAL OPPORTUNITY EMPLOYER U.S. CITIZENSHIP REQUIRED

LEHIGH UNIVERSITY
DEAN
College of Engineering and Applied Science

Lehigh University invites applications and nominations for the position of Dean, College of Engineering and Applied Science. The College is comprised of 129 full-time faculty in six academic departments: chemical engineering, civil engineering, computer science and electrical engineering, industrial engineering, mechanical engineering and mechanics, and materials science and engineering. Engineering enrollment at Lehigh is approximately 1630 undergraduates and 680 graduate students in masters and doctoral programs. The engineering college has a strong tradition of excellence in teaching and research. One of the National Science Foundation's Engineering Research Centers is located at Lehigh University.

The Dean, who reports to the Vice President and Provost of the University, is responsible for providing effective academic, administrative, and fiscal leadership for the College. The Dean holds the rank of Professor with tenure in one of the College's departments. Candidates should possess: (1) an earned doctorate in engineering or applied science; (2) a distinguished record of teaching, research, and scholarship; and (3) the ability to provide academic leadership and to work effectively through consultative decision-making. Successful university experience at the department chairperson or higher level is desirable.

Lehigh University, founded in 1865, is a private institution located in Bethlehem, Pennsylvania. The University consists of four colleges; Arts and Sciences, Business and Economics, Education, and Engineering and Applied Science. Lehigh has approximately 400 full-time faculty with an enrollment of about 4500 undergraduates and 2000 graduate students.

The position will be available July 1, 1991. Review of applications will start in early 1991, and it is anticipated that the selection will be made by May. Women and minorities are encouraged to apply. Applications should submit a letter expressing interest and a resume in confidence to:

Chairperson, Search Committee for Dean
College of Engineering and Applied Science
c/o Provost's Office
Alumni Memorial Building #27
Lehigh University
Bethlehem, PA 18015

An Affirmative Action Equal Opportunity Employer

U.S. Department of Energy
GRADUATE FELLOWSHIP PROGRAMS

CIVILIAN RADIOACTIVE WASTE MANAGEMENT
COMPUTATIONAL SCIENCE
ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT
MAGNETIC FUSION ENERGY TECHNOLOGY
MAGNETIC FUSION SCIENCE
NUCLEAR ENGINEERING AND HEALTH PHYSICS
OPERATIONAL HEALTH PHYSICS

Award Benefits (varies among programs)

- Stipends - $1,200 to $1,800 per month
- Full payment of tuition and fees
- Open to entering and other graduate students
- Appointments for both M.S. and Ph.D. study
- Renewable up to 48 months
- Access to study and research at DOE laboratories

Application Deadline: January 28, 1991
GRE Required for all programs (except Computational Science)

For application forms and additional information, write or call:
Graduate Fellowship Programs
Science/Engineering Education Division

Oak Ridge Associated Universities
P.O. Box 117
Oak Ridge, Tennessee 37831-0117
Phone: (615) 576-9279 or 0128; Fax: (615) 576-0202

Isn't it time we got together?

Consider the personal and professional benefits that only IEEE can offer you.

Being a member of IEEE—the world's largest technical society—makes it easier for you to meet the established professionals in your field; to have ready access to all the latest state-of-the-art information, technical meetings and conferences.

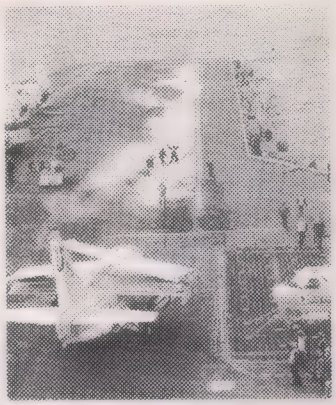
IEEE can be the *single* most vital source of technical information and professional support to you throughout your working career.

No doubt, you're already established in your field. Now gain that competitive edge. Become the best informed—an IEEE scientific/engineering *professional*.

FOR A ***FREE*** IEEE MEMBERSHIP INFORMATION KIT
...Just Dial **1 800 678 IEEE**

MITRE

MITRE is the logical choice . . . For excellence in over 200 systems engineering projects.



For the best systems engineering professionals.

At The MITRE Corporation, we are currently working on over 200 vital, state-of-the-art systems engineering projects for the U.S. Air Force—our principal client—and our other customers including many civil agencies of the U.S. Government. Each project offers an excellent opportunity to demonstrate your expertise. Each one will challenge and expand your technical knowledge. Each one will spotlight your important contributions.

MITRE's systems engineers are making significant contributions to such important C³I programs as GWEN, MILSTAR, BMEWS, AWACS, Joint STARS, and JTIDS. They are involved in a U.S. Navy program to assure position-secure, jam-resistant communications systems for deeply submerged submarines utilizing ELF technology. Involvement in civil projects includes an effort to develop an automated claims system for the Departments of Labor and Health & Human Services; a project to upgrade the Washington-Moscow hotline to permit facsimile transmission; and air traffic control activities for the FAA.

For over 30 years, MITRE's expertise in systems engineering analysis, research, design, and development has been internationally recognized and highly respected—and with good reason. Almost two-thirds of our technical staff have earned advanced degrees. And, just as important, their performance has proven their expertise—and ours—in the creation of systems engineering solutions that work.

MITRE: We offer all the challenge you can handle, all the diversity you could want, plus the top-level recognition you have earned.

U.S. Citizenship required.

Communications

System Design and Analyses • Digital Communications • Microprocessor Applications ▪ Communications Processors (Hardware and Software) • Local Area Networks ▪ Protocol Development/Evaluation • Modulation/Coding Techniques • Secure Communications • Systems Test and Evaluation • Switching and Control Systems • Satellite and Terrestrial Transmission • Survivability/Vulnerability and Electromagnetic Pulse • Line of Sight, Tropo, Millimeter Wave and Fiber-Optics

Command and Control

Air Defense Systems (Deployable and Fixed) • Tactical Air Traffic Control Systems (Deployable and Fixed) ▪ Foreign Air Command and Control • Missile Warning Systems • Satellite Surveillance Systems • Systems Analyses and Specifications • Software Development • Display Technology • Bus-Oriented System Architectures

Computer Systems

Requirements Analyses • Systems Analyses ▪ Systems Architecture and Engineering • Technology Assessment • System Acquisition • Performance Analyses • Simulation and Analytical Modeling ▪ Artificial Intelligence ▪ Image Processing ▪ Fault Tolerant Systems ▪ Local Network Design • Ada ▪ Software Cost Estimation ▪ Computer Security • Software Metrics • Distributed Data Base Systems ▪ Program Verification

Systems Architecture

Advanced Systems Design • Advanced Planning • Intersystems Engineering ▪ Functional/Operational Analyses • Systems Interoperability • Cost Analyses

Radar Systems

Digital Signal Processing ▪ Radar System Surveillance Techniques ▪ Radar System Analyses ▪ Radar System Design ▪ Anti-Jam Analyses • Intelligence Operations Analyses • Embedded Computer Hardware and Software

System Software

On VM/CMS ▪ MVS/ESA • *UNIX*® ▪ VAX/VMS ▪ DOS • OS/2 • Macintosh OS ▪ Design, Implement and Document System Software • Performance Monitoring • Software and Hardware Evaluations ▪ Enhance User Facilities • Applications Software—Corporate, Financial & Administrative Applications; MVS/ADABAS Environment; PL/1 & NATURAL Programming Languages

Software Technology

Knowledge Based Expert Systems • Automatic Programming • Fault Tolerant Systems • Reusable Software

Software Engineering

Performance Simulation • Real-Time Computer Software Analysis and Sizing • Ada Compiler Evaluation • Software Cost Estimation • Project Management Tools • Artificial Intelligence

UNIX is a registered Trademark of AT&T Bell Laboratories.

An Equal Opportunity Employer M/F

BOSTON

For C³I Systems Engineering opportunities, please send your resume to:

David H. Gentes
The MITRE Corporation
4912 Middlesex Turnpike
Bedford, MA 01730

WASHINGTON

For C³I and Civilian Systems Engineering opportunities, please send your resume to:

M.S. Mason
The MITRE Corporation
7525 Colshire Drive
McLean, VA 22102

Research Engineers & Scientists

Digital Signal Processing

The **Environmental Research Institute of Michigan (ERIM),** a growing, leading-edge, research and development organization with headquarters in Ann Arbor, MI, has newly created opportunities for a select group of talented Research Engineers and Scientists for the following areas:

Systems:

- Digital signal processing
- Kalman filtering
- Motion compensation/ navigation systems
- Documentation specialist
- Computer systems manager (networked SUN environment)

Software:

- Real time embedded systems
- Software systems engineering/ simulation/modeling
- User interfaces
- Software testability
- Ada, CASE tools, UNIX, X11, MIL-STD-2167A environment

Hardware:

- RF and microwave design, high speed digital and analog circuit design, microprocessor and interface technology, digital signal processor design.

Previous experience with U.S. Government programs desirable, as is a BS, MS or PhD in Computer Science, Electrical Engineering or Mathematics.

You'll receive an excellent salary with outstanding benefits and growth potential. For prompt consideration, please forward your resume in strict confidence to either: **ERIM, Box 8618, Ann Arbor, MI 48107-8618; or ERIM, 5757 West Century Blvd., Suite 340, Los Angeles, CA 90045 — Attn: Human Resources Manager-IE/11.** An Equal Opportunity Employer. U.S. Citizenship Required.

ERIM

At the Forefront of Sensor Technology

BETTER JOB?
You need us, we need you!

Share in our decade of Success placing **engineers** in hi tech industries **NATIONWIDE**—

• Commercial ▪ Military • $30-80K

ADA, SW/HW, A/D, PWB, ATE, QC, VLSI, RF, EW, MMIC, EMI, Radar, AI, Electro-Optics, Antennas, Microwaves (R&D, design, test, mfg., marketing, program mgmt.)

Send resume & geographical preferences for prompt evaluation. No fees. U.S. citizenship & experience req'd.

Lyon Associates
P.O. Box 568, Amherst, NY 14226
716-839-0690

OPPORTUNITIES IN HIGH-TECH ELECTRONICS, MANUFACTURING, HARDWARE & SOFTWARE ENGINEERING

TC TECHNICAL CAREERS

John Cissell
2175 Credit Union Lane
Suite 504 (Div. of Power Services)
N. Charleston, SC 29418
803-572-3000
——— *and* ———
Dick Berg
10150 Sorrento Valley Road
Suite 314
San Diego, CA 92121
619-458-1323
——— *and* ———
Kim Hetler
255 Route 12, Suite 201
Groton, CT 06340
203-446-9930

All Fees Paid by Client Companies/EEOC

The University of Minnesota
Institute of Technology
Department of Computer Science

The Department of Computer Science invites applications and nominations for two endowed chairs at the tenured professor rank. The recent establishment at the University of Minnesota of the Army High Performance Computing Research Center and the continuing development of the Minnesota Supercomputer Institute and of the Department of Computer Science will permit the holders of these chairs unusual opportunities for leadership in research, education, and outreach activities.

The William Norris Land-Grant Chair in Large Scale Computing is a new endowed chair named in honor of William Norris, founder and Chairman Emeritus of Control Data Corporation. The holder of this Chair must have an outstanding research and scholarly record, a commitment to teaching, and a desire to lead the development of a nationally recognized program in the computer science aspects of large scale computing. Emphasis is placed in the following areas of activity: methods and software for large scale computing, visualization, computer graphics, and high performance computer architecture.

The U.S. West Land-Grant Chair in Telecommunications is a new chair endowed by U.S. West Communications and U.S. West Advanced Technologies. The holder of this Chair will provide leadership for the development of a nationally recognized program of research, instruction, and industrial collaboration in the area of software technology applied to integrated broad band communications and computing environments, network architecture and protocol design for broad band high speed communications, interconnection of local area networks, and performance analysis and modeling of multi-media communications. The Chair holder must have an outstanding research record, a commitment to teaching, and a desire for active participation in industrial collaboration.

Interested persons should contact *either* Professor Ben Rosen, Chair of the Norris Land-Grant Chair Search Committee, *or* Professor David Du, Chair of the U.S. West Land-Grant Chair Search Committee, Department of Computer Science, University of Minnesota, 200 Union Street, Minneapolis, Minnesota 55455. Telephone (612) 625-1890. Deadline for nominations and applications is February 28, 1991.

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women, minorities, and persons with disabilities.

DISCOVER "E" ™

Engineering Our Environment

National Engineers Week
February 17-23, 1991

Job Title:
Product Engineer I

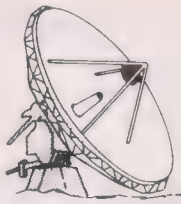
Hours/Wk.: 40
Work Schedule:
8:00 AM-4:30 PM, M-F
Wage: $3,675 per month
Job Duties:
Create computer models of complex electronic, electrohydraulic and electropneumatic mechanical control systems for transmission and truck components; design control algorithms and software.

Education & Experience:
Position requires a minimum of a Master of Science degree in Electrical Engineering, with at least 5 years experience as a Product Engineer-Controls. The 5 years experience must include systems modeling using computers and the design of control hardware and software based on the results thereof. Must have made extensive use of adaptive control theory in these efforts.

In lieu of 5 years work experience, will accept a Ph.D. degree with a thesis on adaptive control systems.

Employer Paid Ad

Send resumes to **MESC, Reference No. 42890, 7310 Woodward Ave., Room 415, Detroit, MI 48202.**



SATELLITE SYSTEMS ENGINEER

Join a fast growing industry leader! Pacific Telecom, Inc. needs a Senior Satellite Systems Engineer in its Alaskan long-lines engineering group. PTI's subsidiary, Alascom, Inc., is the principal long distance carrier in the state of Alaska. Our engineers work in Vancouver, WA and plan the growth and evolution of a satellite, fiber optic and microwave network that includes the Aurora Spacecraft (Satcom F5) and over 200 Alaskan and CONUS earth stations.

As part of this team, you will:

- Plan, engineer and price additions and upgrades to Alascom's satellite network.
- Evaluate equipment and technology alternatives for optimum efficiency, reliability and quality.
- Participate in new equipment installation, performance testing and operational evaluation.
- Work on a wide variety of modulation and multiple access techniques, general earth station design and hardware selection.

The position requires a BSEE and 6 years' progressively responsible engineering experience in all aspects of satellite communications and project management.

Vancouver, Washington is located across the Columbia River from Portland, Oregon in the heart of the Pacific Northwest, a region with outstanding educational, cultural and recreational resources.

PACIFIC TELECOM

For immediate consideration, submit resume to: PACIFIC TELECOM, INC., Dept #89-324-H, P.O. Box 9097, Vancouver, WA 98668-8707. Resumes must be received no later than December 21, 1990. Principals only. Equal opportunity employer.

EBI/SBI/ POLY

USE YOUR "TICKETS" FOR FASTER CAREER GROWTH

Put our 25+ years experience placing technical professionals to work for you. All fees paid. Nationwide opportunities in Communications, Defense, Intelligence, Computer, Satellites and Analytical Sciences. If you earn over $32,000, we have a better, more rewarding job for you . . . right now. U.S. citizenship and EBI/SBI/POLY desirable. Call (301) 231-9000 or send your resume in confidence to: Dept. EAI3EB. Or FAX to: (301) 770-9015.

WALLACH
associates, inc.

Washington Science Center
6101 Executive Boulevard
Box 6016
Rockville, Maryland 20849-6016

Search

CAREER/SCOPE™

RESEARCH LABORATORIES

Become part of our team of top-notch research scientists in the development of advanced technology. Do it at Hughes Aircraft Company's Research Laboratories in Malibu, California, a world leader in electro-optics.

We are expanding our activities in the areas of liquid crystal and solid state spatial light modulators, diffraction optics, holography and beam control devices. We have an immediate opening for a:

MEMBER OF THE TECHNICAL STAFF—Working in the Spatial Optical Processors and Transducers Section, you will conduct studies to evaluate photoconductor materials, electrical driving schemes (CCD, active matrix), and modulators (liquid crystals, solid state). You will then evaluate their integration into spatial light modulator configurations. These devices are developed for applications in display systems (HDTV), optical processing, adaptive optics, and laser beam control.

Experience in one or more of the following areas is required:

- Semiconductor Physics
- Solid State Device Physics
- CCD/CTD Technology
- MOS Devices
- Liquid Crystal Devices
- Display Device Technology
- Diffraction Optics
- Holography
- Kinoform (Binary Optics)

A PhD in Solid State Physics, Electrical Engineering, or Materials Science is desired.

Hughes Aircraft Company offers an attractive salary and an outstanding benefits package, including tax deferred savings; medical, dental and vision coverage.

For immediate consideration, send your resume to: Lynn W. Ross, Hughes Aircraft Company, Research Laboratories, Dept. SEEEI-1290, 3011 Malibu Canyon Road, Malibu, CA 90265. Proof of Legal Right to work in the U.S. is required. Equal Opportunity Employer.

HUGHES
RESEARCH LABORATORIES

Graduate Assistantships in Optics at CREOL

The Center for Research in Electro-Optics and Lasers (CREOL) at the Univesity of Central Florida is seeking highly qualified applicants for a number of Graduate Assistantships in optics. Stipends range from $11,000 to $14,000 for 12 months. Exceptional students will be considered for assistantship enhancements up to $4,000 through the Litton Foundation and United Technologies Optical Systems. Degrees of MS and Ph.D. in Engineering and Physics are offered at UCF. CREOL has 28 faculty positions devoted to lasers and optical sciences and engineering. The academic program includes basic Electrical Engineering and Physics courses as well as, 23 specialized courses in electro-optics and lasers. Current research activities include: laser propagation, laser/material interaction, nonlinear optics, integrated-optics, infrared systems, optical signal processing, laser development, detector technology, ultrafast phenomena, x-ray sources and lithography, nonlinear optical spectroscopy, diffractive optics, thin film optics, metal vapor lasers, free electron lasers, optoelectronics, growth of nonlinear and laser host materials, superconductivity, solid state and micro lasers, and others.

Applications are invited from students with an excellent academic record and fluent command of the English language. Completed applications are due by March 15, 1991. To receive an application package, write to:

CREOL – University of Central Florida
Graduate Affairs Committee
12424 Research Parkway, Suite 400
Orlando, Florida 32826

Innovative people making technology work.

Varian's Research Center, located at its world headquarters in Palo Alto, is currently seeking:

Group Leader –
Radiation Therapy Technology

We're looking for an individual with strong technical and communication skills to direct R&D activities in:

- **Medical Accelerators**
- **Simulators**
- **Portal Imaging**
- **Treatment Planning**

In this high visibility position, a PhD in Physics or Electrical Engineering is required plus 10 years of relevant experience.

Varian offers competitive salaries and a comprehensive benefits program designed to respond to your individual needs. Please send your resume to: Varian Associates, 3075 Hansen Way, M/S K260-DC, Palo Alto, CA 94304. We are an equal opportunity employer.

varian

SAUDI CONSOLIDATED ELECTRICITY CO., IN THE WESTERN REGION JEDDAH - SAUDI ARABIA

COMPUTER OPPORTUNITIES

The Company (SCECO – EWR) is an electric utility covering all the Western region in Saudi Arabia. SCECO – EWR apply modernized and consolidated information systems using three Main – Frame computers located in Jeddah, Makkah & Madina are linked together through leased lines. Applications from competent professionals with high skills for the following positions are welcomed.

1– DATA BASE ADMINISTRATOR:
Applicants should have minimum of 5 years experience in data base design and analysis, 2 of which on IBM DB2, Experience of SQL/DS to DB2 migration and Graphical Data Base are an advantages. Applicant will be respoinsible for new DB2 implementation and will be involved in the migration from SQL/DS to DB2. Candidate will develop and maintain the cooperate data model throughout the information engineering life cycle.

2– SENIOR SYSTEM PROGRAMMER:
Applicants must have a minimum of 7 years experience as MVS/XA system programmer (i.e. JES2, DFP, etc.) experience in MVS/ESA and DFSMS would be considered of high privileges. Previous experience in VSE/SP migration to MVS/XA will also be an advantage. Applicant will be responsible of installing, maintenance and tuning a MVS/ESA installation.

3– SENIOR APPLICATION ANALYST:
Applicants should have a minimum of 10 years in engineering and scientific applications. Previous experience in an electric power utility will be highly considered. Proficiency in data functional analysis techniques and power system modelling, and a working knowledge of information engineering using GIS (AM/FM) will be a privileged.

EWR ENVIRONMENT:
HARDWARE: THREE IBM 4381 + LARGE NUMBER OF IBM PC.
SOFTWARE: VSE/SP POWER, VTAM, NCP, CICS/VS, SQL/DS ICCF, SDF, VSAM, COBOL
Planned to have IBM ES/9000, MVS/ESA, DB2, GFIS (AM/FM), CSP

GENERAL REQUIREMENT:
Fluency in english and good experience in Software/Hardware environment similar to EWR'S.

EWR OFFER:
Attractive salaries and other benefits according to qualifications and experience. Career development, Tax free Country. . .etc. Please apply in confidence with your C.V. and salary before 31/1/1991 to:

PERSONNEL DEPARTMENT – RECRUITMENT SECTION
ELECTRICITY OF WESTERN REGION – P. O. BOX 9299
JEDDAH 21413
KINGDOM OF SAUDI ARABIA

CLASSIFIED EMPLOYMENT OPPORTUNITIES

The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

Advertising rates

Positions open: $34.00 per line, not agency-commissionable
Positions wanted: $34.00 per line, a 50% discount for IEEE members who supply their membership numbers with advertising copy

All classified advertising copy must be received by the 25th of month, two months preceding date of issue. No telephone orders accepted. For further information contact Theresa Fitzpatrick, 212-705-7578.

IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic
Positions Open

Oregon State University—The Department of Electrical and Computer Engineering invites applicants for ■ tenure-track faculty position at Assistant/Associate Professor level. The specific area of interest is parallel computer architectures. Candidates must have an earned doctorate in electrical/computer engineering, the ability to teach effectively, and a commitment to develop ■ significant sponsored research effort. With ■ faculty of 27, the department enrolls 600 undergraduate and 80 MS/PhD students. Regional corporations such as Hewlett-Packard, INTEL, MENTOR, NCUBE, Tektronix, and others support computer engineering research in the Department. The Department recently expanded its facilities with the addition of ■ new building. Located in the Willamette Valley 80 miles south of Portland, OSU and the city of Corvallis offer unsurpassed livability in a quality environment. Applications must include a comprehensive resume, a list of three professional references, and ■ letter of interest. Address applications and inquiries to Dr. Patrick M. Lenders, Chair, ECE Department Faculty Search Committee, Department of Electrical and Computer Engineering, Oregon State University, Corvallis, OR 97331-3211. Review of applicants will begin immediately and continue until the position is filled. Oregon State University is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the rehabilitation Act of 1973. OSU has a policy of being responsive to the needs of dual career couples.

Electrical Engineering. Faculty Openings. Louisiana Tech University. Applicants with an earned doctorate will be judged on effective teaching, ability to improve the growing graduate program, and potential for initiating funded research. Particular emphasis will be given to the areas of digital and microprocessor circuits, computer architecture, and parallel processing. All materials, including letters from references, transcripts, and indication of visa status, etc. will be considered at the first of each month, starting December 1, 1990, until all positions are filled or until final cutoff on May 31, 1991. Send resume and three references to: EE Search, College of Engineering, Louisiana Tech University, Ruston, LA 71272. Louisiana Tech University is an Equal Education and Employment Institution.

University of California, Santa Barbara, Electrical and Computer Engineering. Applications ■■ invited for at least three tenure-track assistant professor positions, available effective 7/1/91, for candidates experienced in image processing/computer vision/speech processing, parallel algorithms, electromagnetics, or imaging technology (including optical processing). Normally, completion of a doctorate is required at the time of the appointment. Candidates should have an established research reputation or outstanding research potential, the ability to attract external research funding, and a strong commitment to teaching at the undergraduate and graduate levels. Applicants should send their resumes and the names and addresses of at least four professional references to: Faculty Search Committee, Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA 93106. Applications will be received until the positions are filled. Proof of U.S. Citizenship or eligibility for U.S. employment will required prior to employment (Immigration Reform and Control Act of 1986). An Equal Opportunity/Affirmative Action employer.

University of Rochester, Electrical Engineering. The faculty is seeking applications from individuals who are active in digital signal processing, optocommunication systems, computer engineering, ASIC design, or related areas. These individuals would contribute to existing faculty groups in image & signal processing, ultrasound & medical ultrasound, superconducting electronics, ultrafast phenomena, computer systems, design automation, integrated circuit design & testing, and networking. Applicants should have an established research record, or a commitment to establish such a record. Those appointed are expected to develop independent or cooperative research efforts and participate in undergraduate and graduate teaching. Appointments are usually made at the Assistant Professor level, tenure track. However, higher level appointments may be made in exceptional cases. A Doctorate in Electrical Engineering or a closely related field is required. Applicants should send ■ full resume, ■ statement of research plans, and copies of relevant publications to: Professor Edwin Kinnen, Chair, Dept. of Electrical Engineering, University of Rochester, 517 Computer Studies Bldg., Rochester, NY 14627. The University of Rochester is an Equal Opportunity Employer (M/F) and specifically invites and encourages women and minorities to apply.

The Department of Electrical Engineering at the University of Maine invites applications at all ranks for a tenure track position in power engineering beginning January or September, 1991. Applicants should have an earned doctorate. The successful candidate will be expected to contribute to undergraduate and graduate teaching in the electric power area and to establish a research program. Opportunities exist to cooperate with several local power companies. Salaries are competitive and arrangements are made to assist junior faculty in initiating ■ research program. Applicants must send a resume which clearly indicates citizenship/visa status, a statement concerning teaching and research interests and a list of three references to: EE Search Committee, Barrows Hall, University of Maine, Orono, ME 04469. Applications from women and minorities are particularly encouraged. Review of applications will begin immediately and continue until February 15, 1991 or until the position is filled. The University of Maine is an Equal Opportunity/Affirmative Action Employer.

San Jose State University Electrical Engineering Department. Applications are invited for entry-level tenure-track faculty positions at the Assistant Professor rank. Positions are available in computer and multiprocessor design, microprocessor design, microprocessor application; analog and digital electronics, including CAD and VLSI; DSP architecture and application; circuits, systems and signal processing. Earned doctorate in Electrical Engineering is required. Positions are limited to U.S. citizens or permanent residents. Research, consulting and summer employment opportunities are available. The University is the oldest and one of the largest in the California State University System. It is located at the southern end of San Francisco Bay in the heart of Silicon Valley. Resume and names and addresses of three references should be submitted to Dr. Ray R. Chen, Chair, Department of Electrical Engineering, San Jose State University, San Jose, California, 95192-0084. San Jose State University is an equal opportunity/affirmative action/Title IX employer. Women and minorities are especially encouraged to apply.

University of Illinois at Chicago—Instructorships and Tenure-Track faculty positions in electrical engineering and computer science at both the junior and senior level are available. Rank and salary commensurate with qualifications. An earned Doctorate in EE or CS must be completed by date of appointment, but not for the instructorships. Demonstrated teaching and research abilities are highly desirable. For full consideration, please send resume, list of publications, and the names of at least three references by April 30, 1991, to Dr. Wai-Kai Chen, Head, Department of Electrical Engineering and Computer Science (M/C 154), University of Illinois at Chicago, P.O. Box 4348, Chicago, IL 60680. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

The Mechanical Engineering Department at Carnegie Mellon University invites applications for a tenure-track position at the Assistant Professor level Commencing September 1991 in the area of Robotics and Controls. This position is joint with the Robotics Institute at Carnegie Mellon. Applicants must have ■ Ph.D. in Mechanical Engineering (or closely related field). Duties include teaching undergraduate and graduate courses, and research. Appointments at ■ higher rank will be considered for qualified applicants having a proven record of grant support. Submit application, complete resume, and names of three references to Professor G.B. Sinclair, Mechanical Engineering Department, Carnegie Mellon University, Schenley Park, Pittsburgh, PA 15213-3890. Closing date for applications is February 15, 1991. Carnegie Mellon University is an affirmative action/equal opportunity employer.

Clemson University. Department of Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at Clemson University invites applications for tenure/tenure-track positions, primarily at the assistant professor level. A Ph.D. is required. Candidates with research interests in one of the following areas are sought: communications and digital signal processing; networks and distributed computing; quantitative analysis of computer architectures; electromagnetic analysis of active devices (microwave, millimeter wave, or electro-optic); and multidisciplinary applications in power systems (e.g. power and artificial intelligence; power and computer communications). A successful candidate must exhibit exceptional potential for research and teaching. Clemson University's College of Engineering was listed as one of the United States' "up-and-coming" engineering graduate programs in the March 19, 1990, issue of U.S. News and World Report. The ECE Department comprises thirty-six full-time faculty, approximately 700 undergraduate students, and 140 graduate students. It offers B.S., M.S., and Ph.D. degrees in both electrical engineering and computer engineering. Facilities and/ or groups

bearing on the areas indicated above include the Clemson University Electric Power Research Association (CUEPRA); ■ microcircuits reliability research group with a class 100 clean room; automated microwave measurement facilities to 26 GHz; an image processing laboratory; a Center for Computer Communication Systems. Resumes, supported with a list of references, should be sent to L. Wilson Pearson, Head; Department of Electrical and Computer Engineering; 102 Riggs Hall; Clemson University; Clemson, SC 29634-0915. Initial screening of applicants will begin January 15, 1991 and continue until positions are filled. Clemson University is an Equal Opportunity/Affirmative Action Employer.

University of Southern California. The Department of Electrical Engineering-Systems at the University of Southern California has faculty positions available at the Assistant, Associate for Full Professor level in the following areas: Communications Science (optical communications with an experimental emphasis, digital signal processing), and Signal and Image Processing (algorithm oriented; and, hardware for signal processing-analog, digital). Computer Engineering within the Electrical Engineering-Systems department is expanding, and looking to fill positions in the following areas: VLSI/CAD, networks (optical type), and architecture with an emphasis on hardware. Additionally, we are looking for a full-time instructor (M.A. only required) to support the Computer Science/Computer Engineering undergraduate degree program. For all openings, please send a resume and the names of at least three academic reference to Jerry M. Mendel, Chairman, Department of Electrical Engineering-Systems, University of Southern California, Los Angeles, CA 90089-0781. USC is an equal opportunity/affirmative action employer.

Brigham Young University-Computer Science Department. Applications are invited for an Assistant Professor position in Communications/ Networking or Software Engineering beginning September 1991. Candidates must have a Ph.D. in Computer Science Applicants should send a curriculum vita to E. Daniel Johnson, 3362 TMCB, Brigham Young University, Provo, UT 84602.

University of Maryland Baltimore County Dept. of Electrical Engineering anticipates several openings for tenure-track positions. The rapidly expanding program is part of the Electrical Engineering Department of the University of Maryland system. We are seeking candidates in the areas of digital signal processing and optical communications to strengthen ongoing efforts in image processing, pattern recognition, modulation and coding, and signal processing and to complement our existing experimental photonics program. Candidates should expect to teach undergraduate/graduate electrical engineering courses and conduct research in their areas of specialization. Rank and salary commensurate with qualifications. Send resume, list of three reference and a statement of research interests by April 1, 1991 to Dr. Gary M. Carter, Chairman Faculty Search Committee, Department of Electrical Engineering, University of Maryland Baltimore County, Baltimore, MD 21228-5398. UMBC is an EO/AA employer.

Penn State Kirby Chair Electrical and Computer Engineering. Applications/nominations are invited for the endowed Kirby Chair of Electrical and Computer Engineering at The Pennsylvania State University, available Spring or Fall Semester, 1991. This Chair honors Mr. Robert E. Kirby, retired board chairman and chief executive officer of Westinghouse Electric Corporation. The Chair, endowed at a level of $1,000,000 is joint gift from Mr. Kirby and the Westinghouse Foundation. Candidates should hold a Ph.D. degree in Electrical/Computer Engineering or ■ related discipline, have outstanding accomplishments, a capability of establishing a strong research program, and a desire to teach at both the undergraduate and graduate levels. The Department of Electrical and Computer Engineering at Penn State currently has over 50 faculty, 800 junior and senior level students and 280 graduate students. Funded research is being conducted in many areas, including: Electromagnetics; Electro-Optics; Signal Processing; Computer Hardware, Software and Applications; Power; Electronic Materials and Processing; Communications; Control and Robotics. The Kirby Chair position is open to qualified candidates in all areas of Electrical and Computer Engineering. Please send resume and cover letter, with names, addresses and phone numbers of at least three references to: Faculty Recruiting Committee, Department of Electrical and Computer Engineering, Box IEEE-K, 129 EE East, The Pennsylvania State University, University Park, PA 16802. Applications received by December 31, 1990 will be assured of consideration. However, applications will be considered until position are filled. An Affirmative Action/ Equal Opportunity Employer Women and Minorities Encouraged to Apply.

E.E. Faculty Positions at Auburn University. E.E Department currently has openings for faculty with expertise in any of the following areas: computer engineering, VLSI design, electronic circuit design or power engineering. Applicants must be research oriented, have a Ph.D. and an electrical engineering background. Senior level appointments are available. Foreign national applicants must clearly indicate visa status. Auburn is Alabama's land-grant university with 22,000 students. The E.E. Department has 30 faculty and currently enrolls approximately 750 undergraduate and 120 graduate students. The annual research funding level is approximately $3 million. Interested persons may send resumes to Professor L.L. Grigsby, Chairman of Faculty Search Committee, Department of Electrical Engineering, Auburn University, AL 36849-5201. Minorities and women are encouraged to apply. Auburn University is an equal opportunity and affirmative action employer.

Penn State Faculty Positions Electrical and Computer Engineering. Applications are invited for several tenure-track faculty positions in the Department of Eelectrical and Computer Engineering at The Pennsylvania State University, to begin Fall Semester, 1991. Candidates should have a Ph.D. in Electrical/Computer Engineering or a related discipline, ability to establish a strong research program, and a desire to teach at both the undergraduate and graduate levels. Although candidates in all areas will be considered, the following areas will receive priority consideration: Computer Engineering, Electromagnetics, Electro-optics, Semiconductor/Electronic Materials Processing and Power Systems. The Department of Electrical and Computer Engineering at Penn State currently has over 50 faculty, 800 junior and senior level students, and 280 graduate students. Funded research is being conducted in many areas, including: Electromagnetics; Electro-optics; Signal Processing; Computer Hardware, Software and Applications; Power; Electronic Materials and Processing; Communications; Control and Robotics. Please send resumes and cover letters, with names, addresses and phone numbers of at least three reference to: Faculty Recruiting Committee, Department of Electrical And Computer Engineering, Box IEEE-F, 129 EE East, The Pennsylvania State University, University Park, PA 16802. Applications received by December 31, 1990 will be assured of consideration. However, applications will be considered until positions are filled. An Affirmative Action/ Equal Opportunity Employer Women and Minorities encouraged to Apply.

Penn State Director of Computer Engineering. Applications/nominations are invited for the position Director of Computer Engineering in the Department of Electrical and Computer Engineering at The Pennsylvania State University available Spring or Fall Semester, 1991. Candidates should have a Ph.D. in Electrical/Computer Engineering or a related discipline, an established reputation in Computer Engineering, strong leadership qualities, and ability to attract research funding. It is anticipated that the position will be a the rank of Full Professor with tenure. The Department of Electrical and Computer engineering at Penn State currently has over 50 faculty, 800 junior and senior level students, and 280 graduate students. The Compute Engineering Program is within the Department of Electrical and Computer Engineering. About 12 faculty members, 100 junior and senior level students, and 50 graduate students belong to this program, which awards B.S., M.S. and Ph.D. degrees in Computer Engineering. Research activities currently exist in Parallel and Distributed Processing, Interconnection Networks, Fault Tolerant Computing, Image Processing and Compute Vision Database Systems, VLSI, and Computer Communication. Applications received by December 31, 1990 will be assured of consideration. However, applications will be considered until positions are filled. Please send resume and cover letter, with names, addresses and phone numbers of at least three references to: Faculty Recruiting Committee, Department of Electrical and Computer Engineering, Box IEEE-D, 129 EE East, the Pennsylvania State University, University Park, PA 16802. An Affirmative Action/Equal Opportunity Employer Women and Minorities Encouraged to Apply.

Texas A&M University. The Electrical Engineering Department has several openings for tenure track faculty at all ranks. Applicants must have a Ph.D. degree. For senior positions, the individuals should have ■ proven record of scholarly contributions, and for junior positions, demonstrated potential for quality research and teaching is necessary. The salary is competitive and commensurate with qualifications and experience. The Department has 1300 undergraduate students, 350 graduate students and a faculty of 56. Currently the active areas of graduate programs include digital and analog microelectornics , electronic and magnetic materials and devices, electromagnetics, micorowave engineering, computer engineering, electrooptics, telecommunications, controls, signal processing, electric power systems, and power electronics. Qualified individuals having expertise in any of these research areas are urged to apply. The Department has a particular interest in hiring outstanding faculty in the areas of computer engineering, microelectronics, electronic materials, electromagnetics, microwave engineering, power systems automation, solid state electronics and signal processing. Applicants should send a complete resume, including names and addresses of three references to Dr. J.W. Howze, Department Head, Electrical Engineering Department, Texas A&M University, College Station, TX 77843. Texas A&M University is an equal opportunity/ affirmative action employer, and actively seeks the candidacy of women and minorities.

Stanford University Faculty Openings—The Departments of Computer Science and Electrical Engineering have openings for both tenure-track and research faculty positions. These positions are affiliated with the Computer Systems Laboratory, ■ joint laboratory within the two departments focusing on teaching and research in computer systems. Applications are invited. Applicants should have received a Ph.D. in Computer Science or Electrical Engineering prior to September, 1991. We are looking for candidates with demonstrated research ability in one or more areas of computer hardware and software, including programming languages, and operating systems. All applicants will be considered for positions beginning in the Fall Quarter of 1991. Stanford University is an affirmative action, Equal Opportunity Employer and welcomes applications from women and minority groups. Please submit a detailed resume including five references, with at least one reference outside your current institution. Applications should be sent to: Professor John Hennessy, Search Committee Chairman, Computer Systems Laboratory, Department of Electrical Engineering, Stanford University, Stanford, California 94305-4055. Applications should be sent prior to February 1, 1991.

California State University, Northridge: The Department of Electrical and Computer Engineering has a tenure track opening at Assistant Professor level in the area of microwave active circuits, and a number of lectureships in the areas of electronics, controls, and communications effective Fall 1991. Candidates with a strong interest in teaching and good communication skills are encouraged to apply. An earned doctorate in Electrical Engineering and some evidence of scholarly work/ industrial experience are preferred. However, candidates with a Master's Degree in Electrical Engineering and at least 5 years of industrial/teaching experience will also be considered. Successful candidates will be required to teach ■ variety of graduate and undergraduate courses. Applicants must be legally qualified to work in the U.S. and must clearly specify the position for which they are applying. The campus is part of

the California State University System and is located in a northern suburb of Los Angeles. Applicants should send a letter of applications, along with a resume and names and telephone numbers of at least three references, postmarked Jan. 18, 1991 or earlier to Dr. Jagdish C. Prabhakar, Chair; Department of Electrical and Computer Engineering; California State University, Northridge; Northridge, CA 91330. CSUN is an Equal Opportunity/Affirmative Action Employer.

Vacancy Announcement. University of Idaho—Faculty Positions. Electrical Engineering, University of Idaho invites applications for tenure track positions at the assistant professor level; however, outstanding applicants at higher levels will also be considered. While specialization in digital systems, electronics, power, or electromagnetics is desired, outstanding candidates in all areas are encouraged to apply. Qualifications for each position include an earned PhD in electrical engineering or ■ closely related field, excellent teaching ability, potential for establishing ■ strong research program and US citizenship or permanent residency. Successful applicants will teach at the undergraduate and graduate levels and conduct research with graduate students in appropriate specialty areas. The Department offers BS, MS, MEngr, and PhD degrees in electrical engineering and BS, MS, and MEngr degrees in computer engineering. The University of Idaho is the landgrant university in Idaho and has statewide responsibility for engineering education. The main campus is located in Moscow, in the heart of the Palouse region of northern Idaho approximately 10 miles from Washington State University in Pullman, Washington. The University of Idaho has over 9,000 students, and the Department of Electrical Engineering has approximately 320 undergraduate students, 50 full-time graduate students, and 16 faculty. Active areas of research include power, analog electronics, control systems, communications, digital systems, and very large scale integrated (VLSI) circuits. The Microelectronics Research Center (MRC), established within the College of Engineering in 1985, concentrates on the design of VLSI computer chips. The MRC was recently selected as one of nine Space Engineering Research Centers by NASA. Applications will be accepted until the positions are filled; closing date will be no earlier than February 1, 1991. Send letter, resume, and names of three references to Dr. John E. Purviance, Department of Electrical Engineering, University of Idaho, Moscow, Idaho 83843-4194. The University of Idaho is an EO/AA employer and educational institution.

Illinois Institute of Technology, Department of Electrical and Computer Engineering invites applications for tenure track and tenured faculty positions in the areas of computer, communication, electromagnetics, and power. Please send resume to Chair of Faculty Search Committee, Department of Electrical and Computer Engineering, Illinois Institute of Technology, Chicago, Illinois 60616. IIT is an equal opportunity/affirmative action employer.

Faculty Position—Ohio University: Applications are invited for a tenure-track faculty position with a specialty in control systems. The opening is immediately available. Duties include teaching at the graduate and undergraduate levels and obtaining and participating in sponsored research. Preference will be given to those candidates that have a demonstrated record or show potential for attracting externally supported research. Applicants must have a Ph.D. or equivalent. The position will be filled at the Assistant or Associate levels, depending on qualifications. The Electrical and Computer Engineering Department has the Stocker Endowment, worth more than $6 million, to support research and graduate education. The department is housed in the $12M Stocker Center and has more than $2.2M per year in sponsored research. The Department offers both the M.S. and Ph.D. degrees. To establish research programs, new faculty are given special consideration in terms of equipment budget and summer support. Ohio University provides competitive compensation. Screening of candidates will begin immediately, and applications will be accepted until the position is filled. Send a resume and the names of at least three reference to Dr. Dennis Irwin, Chairman of the Search Committee, Electrical and Computer Engineering Department, Stocker Center, Ohio University, Athens, Ohio 45701-2979. Preference will be given to U.S. Citizens and permanent residents. Ohio University is an equal opportunity and affirmative action employer.

Wright State University Department of Computer Science and Engineering Dayton, Ohio 45435. Applications are invited for the position of Instructor in the Department of Computer Science and Engineering to teach undergraduate courses. Instructor is a non-tenure track position. At least an MS in CS, CEG, or a related discipline is required with some teaching experience preferred. Review for positions will begin December 1, 1990 and continue until filled. Send applications, resume, three references, and official transcripts to Dr. A.D. McAulay, Department of CS&E, Wright State University, Dayton, OH 45435. Wright State University is an EO/AA employer.

Postdoctoral Fellow Grade I/Postdoctoral Fellow Grade II/ Research Fellow; Computer Science Laboratory, Research School of Physical Sciences, Australian National University. Applications are invited for one or two full-time research positions in the Computer Sciences Laboratory. The Computer Science Laboratory studies (1) parallel algorithms and architectures, including systolic arrays, 2-D MIMD arrays, hypercubes and transputer networks; (2) aspects of man-machine systems, including image analysis and processing, speech recognition and speaker characterization. The Computer Sciences Laboratory is located in the Engineering Division of the Research School of Physical Sciences, and is a constituent research group of the Centre for Information Sciences. Research facilities include access to several parallel machines. Applicants with a strong background in any relevant area of Computer Science are invited to apply. Short-term appointments of staff seconded from other institutions will be considered. Further information may be obtained from Professor RP Brent (phone 61 6 2493329, e-mail rpb@phys4.anu.oz.au). Closing date: 31 January 1991. Ref. PS 10.10.1. Salary: Postdoctoral Fellow Grade 1 (fixed point); A$28,792—A$32,762 p.a.; Postdoctoral Fellow Grade II; A$33,163—A$43,096; Research Fellow; A$33,163—A$43,096 p.a. Research Fellow up to three years, possibility of extension to five years; Postdoctoral Fellow up to two years, possibility of extension to three years. Applications should be submitted in duplicate to the Registrar, The Australian National University, GPO Box 4, Canberra ACT 2601, Australia, quoting reference number and including curriculum vitae, list of publications and names of at least three referees. The University reserves the right not to make an appointment or to appoint by invitation at any time. Further information is available from the Registrar. The University is an Equal Opportunity Employer.

Postdoctoral Fellowships in Electronic Imaging. The University of Rochester announces the availability of prestigious two-year postdoctoral appointments to EASTMAN-KODAK FELLOWSHIPS IN ELECTRONIC IMAGING starting on or after 1 January 1991. These are challenging positions for superior scholars who wish to pursue basic research topics in Electronic Imaging and Digital Imaging Science including image processing, photodetector arrays, color science, automatic pattern recognition, and active and passive remote sensing. Research is to be conducted in existing laboratories at the University of Rochester in close cooperation with University faculty and senior engineering scientist from the Eastman-Kodak Company. Qualifications required for these positions include a Ph.D. degree in Electrical Engineering, Optics, Computer Science, or Physics with some specialization in Imaging Science or Electronic Imaging. An excellent mathematical background and extensive computer experience are required. Demonstrated excellence in research (describe thesis) and potential for significant research contributions are major factors in our evaluation procedure. There is also to be an emphasis on developing relevant research on topics that are suitable for funding from external sources. Please send a resume together with a list of three or more professional references and with a brief (4 pages or less) description of your specific research interests. Applications will be considered until the positions have been filled. This is a continuing program of research that is associated with the establishment of a major Consortium dedicated to Electronic Imaging in the Rochester Community. Annual salary is $30,000 to $35,000 based on a 40-hour week. Send applications to the attention of Professor Nicholas George, Associate Dean for Research, Institute of Optics, College of Engineering & Applied Science, University of Rochester, Rochester, NY, 14627. Equal opportunity employer (M/F).

The University of Iowa is seeking outstanding faculty to join the expanding Department of Electrical and Computer Engineering. Applications are invited for tenure track faculty positions at all ranks. Salary will depend on the rank and qualifications. In addition to an earned doctorate, qualifications include the ability to 1) carry out independent research, 2) teach effectively at both the undergraduate and graduate levels, and 3) maintain an externally funded research program. Candidates in Computer Engineering, Photonics and Optoelectronics, and Image Processing and Visualization, will be given special consideration. Women and minorities are especially encouraged to apply. Significant opportunities exist for interdisciplinary research. While maintaining excellent undergraduate programs, the College of Engineering emphasizes graduate education and research. The College is committed to achieving ■ top status for its educational and research programs among public institutions. A wide ranging educational, cultural and recreational environment includes outstanding primary and secondary schools. Positions may be available starting January 1991. Send curriculum vita and the names of three references to: Chair, Faculty Recruiting Committee, Department of Electrical and Computer Engineering, The University of Iowa, Iowa City, Iowa 52242. The University of Iowa is an Equal Opportunity/Affirmative Action Employer.

SUNY Institute of Technology at Utica/Rome. Assistant/ Associate Professor in Photonics. School of Information Systems and Engineering Technology invites applications for a tenure-track position beginning Spring or Fall 1991 in a new, developing program in Photonics. Duties will include teaching, research, and development of the program. The Institute has state-of-the-art laboratories for fiber optics, image processing and vision, telecommunications, lasers, computers and CAD systems. Qualifications: An earned Ph.D. in Photonics/Optoelectronics related discipline is required with specialization in one or more of the following areas: integrated optics; optoelectronic devices and materials (processing fabrication); optical computing and pattern recognition; or optical neural networks. Rank and salary are commensurate with experience. Assistant Professor, Telecommunications—Candidate must possess a solid background in voice/data communications, including hands-on work with a variety of communication equipment involving T-1 multiplexors, DACs, network testing and diagnostics, central office, PBX and wiring plant. Qualifications: Teaching experience and Master's degree required. Ph.D. preferred. Review of applications will continue until both positions are filled. Please submit letter of application and resume (if applying for Assistant/Associate Professor in Phontonics, include three names of reference) to: Mr. Anthony F. Panebianco, Director of Personnel/Affirmative Action, SUNY Institute of Technology at Utica/Rome, Drawer 0019, P.O. Box 3050, Utica, New York 13504-3050. An Affirmative Action/Equal Opportunity Employer.

Department Chair, Electrical and Computer Engineering, West Virginia University. Nominations and applications for the position of Chairperson will be reviewed beginning January 15, 1991 and will continue until the position is filled. Candidates should have a Ph.D. in Electrical Engineering or a related discipline and must present credentials in research, teaching and ongoing scholarly activities which qualify the individual for tenured full professor position. The chairperson must provide leadership and vision for the department and should communicate effectively with alumni, colleagues, other chairs and higher administration within the university. The chairperson is expected to promote research funding from all sources and to address the research and educational needs of the electrical and compute engineering industries. The Department of Electrical and Computer Engineering has 20 faculty positions with research activities and laboratory facilities in the following areas: computers, controls, power systems and electronics, signal processing, microprocessors and engineering design. There are excellent computing facilities

throughout the College of Engineering. A new Engineering Research Building and affiliations with the WVU based National Research Center for Coal and Energy offer considerable development opportunities, Growth in externally funded research is ■ department priority. The Department has approximately 400 undergraduates in electrical and computer engineering programs and 60 on-campus graduate students in the MS and Ph.D. programs. West Virginia University is a land-grant institution. It is the only comprehensive, doctoral granting university in the state and enrolls 20,000 students in 175 degree programs through seven colleges and seven professional schools. Morgantown is a diverse, scenic community of approximately 45,000 with easy access to Pittsburgh, PA, and Washington, DC. Cultural and recreational opportunities are plentiful in the Morgantown town areas. Applications should include a letter of interest, resume, and the names of three references. The salary will be commensurate with qualifications and experience. Women and minorities are encouraged to apply. Send applications and nominations to: Electrical & Computer Engineering Chair Search Committee, c/o Gina Buckhalter, College of Engineering, West Virginia University, P.O. Box 6101, Morgantown, WV 26506-6101. Voice (304) 293-4821, ext. 220, FAX (304) 293-5024. West Virginia is an Equal Opportunity/ Affirmative Action Institution.

Case Western Reserve University, Department of Electrical Engineering and Applied Physics. Applications are invited for tenure-track positions from individuals with ■ dedication to teaching and ■ superior research capability in the areas of Electro-optics, Sensors and Microelectromechanical Systems. Extensive modern facilities and a cooperative spirit create an environment conductive to a productive career at Case. The University is located in Cleveland's cultural center where its neighbors ■■■ the Cleveland Orchestra, three museums and the Cleveland Institute of Music. Moderately priced housing within walking distance is available in attractive residential areas. Send resume with citizenship and the names of three reference to Dr. Sheldon Gruber, EEAP Dept., Case Western Reserve University, Cleveland, Ohio 44106. CWRU is an Affirmative Action/Equal Opportunity Employer.

Professor of Optics—The Institute of Optics, University of Rochester, invites applications for ■ tenure track position as Assistant Professor or Associate Professor of Optics. A Ph.D. degree in Physics, Optics, or Electrical Engineering is required. Particular research interest is optical engineering. The successful candidate will be expected to teach one course per semester and to pursue ■ vigorous program of research. Laboratory space and start-up research funds will be provided. The Institute of Optics offers programs leading to the B.S., M.S., and Ph.D. degrees in Optics and has approximately 150 graduate students in residence at the present time. Qualified women and minority persons are especially urged to apply. Send a resume and names of three reference to: Professor Duncan T. Moore. Director, The Institute of Optics, University of Rochester, Rochester, New York 14627. An Equal Opportunity Employer.

University of California, San Diego. The Department of Electrical and Computer Engineering at UCSD expects to have two tenured/tenure-track faculty positions available starting Fall 1991. One position is available in Computer Engineering at the level of Associate or Full Professor. Of primary interest ■■■ Computer Architecture, Distributed Computing, Parallel Computation, Microprocessor and Microcomputer Design, Advanced Memory System Organization, Software Engineering, Design Automation, VLSI Architecture, Expert Systems and Supercomputer Architecture. A second opening may be available at the junior level; the position involves teaching and research in the area of Electronic Devices and Materials (Electronic Characterization, Processing Science, Ultrahigh Speed Devices, Device Modeling). A Ph.D. degree is required; salary and rank will be commensurate with experience and qualifications. Applications received by the end of January, 1991 will be considered. Interested applicants should send a current resume and the names and addresses of at least three references to: University of California, San Diego, 9500 Gilman Dr., Professor Manuel Rotenberg, Chair, Department of Electrical and Computer Engineering, Mail Code 0407, La Jolla, California 92093-0407. Immigration status of non-citizens should be stated in the dossier. UCSD is an Equal Opportunity/Affirmative Action Employer.

The Department of Electrical Engineering at Tulane University invites applications for two nontenure track instructor positions. Some advantages are: 1) an excellent opportunity for a person with ■ masters degree in electrical engineering to prepare for a career in higher education while working toward the doctorate, 2) nine-month appointment with a salary reasonably competitive with industry, and 3) up to six hours of tuition free graduate study per semester. Existing research emphasizes signal and image processing, communications, control and power systems, and computer systems. Complete vitae, including official undergraduate and graduate transcripts and a minimum of three references, should be sent to Dr. S.T. Hsieh, Chairman, Search Committee, Department of Electrical Engineering, Tulane University, New Orleans, LA 70118-5674. Closing date is March 1, 1991. Tulane University is an equal opportunity/affirmative action employer.

The Department of Electrical Engineering of The University of Texas at El Paso is seeking applications and/ or nominations to fill an endowed chair in the area of computer engineering. The Department is seeking an established researcher/ educator to assume a leadership role in the continued development of its program in this area. Applicants should have a Ph.D. in either electrical or computer engineering. The appointee will be expected to establish and maintain a strong program of research, including extramural funding, develop and teach computer engineering courses at both the graduate and undergraduate level, and provide leadership and mentoring to faculty members and graduate students in computer engineering. The position is available September 1, 1991. Applications will be reviewed starting January 15, 1991. Applications, which should include ■ complete resume and the names and addresses of at least three references, should be sent to Dr. Michael E. Austin, Department of Electrical Engineering, The University of Texas at El Paso, El Paso, Texas 79968-0523. The University of Texas at El Paso is an EEO/AA employer and encourages applications from women and minority group members.

The University of Texas at El Paso, Department of Electrical Engineering, invites applications for ■ tenure-track position at the Assistant Professor level. Applicants will have the opportunity to contribute significantly to the development of a new Ph.D. program. A doctorate in electrical engineering is required. A commitment to teaching both undergraduate and graduate students is expected along with the ability to initiate, conduct and supervise research. The position will be available September 1, 1991. Applications should include ■ resume, the names and addresses of at lest three reference and a statement of current career objectives. Send to Dr. Michael E. Austin, Electrical Engineering Department, The University of Texas at El Paso, El Paso, Texas 79968-0523. Deadline for receipt of applications is February 15, 1991. The immigration status of non-U.S. citizens must be indicated clearly in the application. The University of Texas at El Paso is an EEO/AA employer and encourages applications from women and minority group members.

Electrical Engineering Faculty—The New Mexico Institute of Mining and Technology invites applications for ■ tenure-track Assistant Professor position in the Electrical Engineering Department. A higher-level appointment may be considered for qualified candidates. The Electrical Engineering Department was established in 1989 as an outgrowth of Electronic Options in Physics and Engineering Science, and offers ■ modern undergraduate program in EE and electronics. Applicants must have ■ Ph.D. Degree in Electrical Engineering or a closely related field such as Physics, or Computer Science. The successful applicant will be expected to teach and help develop undergraduate EE courses, including laboratory and design courses. In addition he/she will be expected to develop an active research program. Preference will be given to applicants who will strengthen the department in electronics and signal processing and to individuals who would reinforce existing research programs at Tech. Close ties are possible and encouraged with related Ph.D. granting departments, including Physics and Computer Science, and with organized research activities, including the Langmuir Laboratory for Atmospheric Research and the Very Large Array and Very Long Baseline Arrays of the National Radio Astronomy Observatory. The starting date is August 15, 1991. Applications received before February 14, 1991 will be given full consideration; however, applications will continue to be accepted until the position is filled. Send resume, selected reprints, ■ letter describing research interests, and the names, addresses and telephone numbers of three references to New Mexico Institute of Mining and Technology, Human Resources, Wells Hall Box C-119, Socorro, New Mexico 87801. AAEOE.

Postdoctoral Fellowships in Electronic Imaging. The University of Rochester announces prestigious two-year postdoctoral appointments to XEROX FELLOWSHIPS IN ELECTRONIC IMAGING starting on or after 1 January 1991. These are challenging positions for superior scholars who wish to pursue basic research topics in Electronic Imaging and Digital Imaging Science including image processing, statistical optics, color science, automatic pattern recognition, and active and passive remote sensing. Research is to be conducted in existing laboratories at the University of Rochester in close cooperation with University faculty and senior engineering scientist from the Xerox Webster Research Center. Qualifications required for these positions include a Ph.D. degree in Electrical Engineering, Optics, Computer Science, or Physics with some specialization in Imaging Science or Electronic Imaging. An excellent mathematical background and extensive computer experience are required. Demonstrated excellence in research (describe thesis) and potential for significant research contributions are major factors in our evaluation procedure. There is also to be an emphasis on developing relevant research on topics that are suitable for funding from external sources. Please send a resume together with ■ list of three or more professional references and with ■ brief (4 pages or less) description of your specific research interests. Applications will be considered until the positions have been filled. This is a continuing program of research that is associated with the establishment of a major Consortium dedicated to Electronic Imaging in the Rochester Community. Annual salary is $30,000 to $35,000 based on ■ 40-hour week. Send applications to the attention of Professor Nicholas George, Associate Dean for Research, Institute of Optics, College of Engineering & Applied Science, University of Rochester, Rochester, NY, 14627. Equal opportunity employer (M/F).

North Dakota State University. The Department of Electrical and Electronics Engineering at North Dakota State University invites applications for tenure-track faculty positions. Applicants should show evidence of teaching and research ability and match departmental goals. They must hold a Ph.D. or equivalent by September 1, 1991 and communicate effectively in English. Assistant professor level preferred. Duties will include undergraduate and graduate teaching, research, and service. The department currently needs people in the following areas: (1) computer engineering (2) control systems, and (3) analog electronics. Exceptional applicants in other areas may also be considered. Applications with resume along with the names, addresses, phone numbers, and e-mail addresses (optional) of three references should be addressed to Dr. Noel W. Anderson, Faculty Search Committee, Department of Electrical and Electronics Engineering, P.O. Box 5285, North Dakota State University, Fargo, North Dakota 58105. Applications will be considered beginning December 1, 1990 and continuing until positions are filled. NDSU is an equal opportunity institution.

Engineering Technology—Department Head: Lake Superior State University is seeking ■ qualified candidate to fill ■ 10-month position as Department Head in the Engineering Technology Department, beginning July 1, 1991. The Department Head is responsible for the leadership, management and administration of an Engineering Technology program of 400 students.

The Department Head makes recommendations on all faculty personnel matters; allocates and manages the budget; provides leadership in curricular matters; arranges for physical facilities; stimulates and coordinates scholarly activities; and teaches engineering courses. Lake Superior State University places a primary emphasis on quality teaching. Programs are offered in Mechanical, Electrical, Computer, Automated Systems, and Drafting and Design Engineering Technology. All programs are accredited by the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology. Qualifications: Master's Degree in Engineering or appropriate related discipline required. Doctorate and/or registration as ■ Professional Engineer preferred. Substantial teaching, administrative or industrial management experience required. Please send letter of application, resume, and three letters of references to the Office of Employee Relations, Lake Superior State University, Administration Building, Sault Ste. Marie, MI 49783. Application Deadline: February 1, 1991. An Equal Employment Opportunity/Affirmative Action Employer.

Polytechnic University Department of Electrical Engineering Faculty Positions. The Polytechnic is ■ private university with more than 700 undergraduates following programs in EE, as well as over 150 full time and 450 part time graduate students working for degrees in EE, Electrophysics and Systems Engineering. Applications are invited for tenure track positions from individuals with PhD degrees appropriate for teaching and research in the areas listed below. Current areas of greatest faculty need are Opto-Electronics devices and systems for telecommunications and computers), Physical Electronics (behavior of quantum scale devices) and Digital Systems (VLSI design, architecture, microprocessors). Need also exists for faculty in the areas of Controls (automation, robotics) Telecommunications (high speed networking, software, protocol design) Power (power electronics, electronic drives) and Plasmas (wave-plasma interactions). The department has an annual research expenditure of over $4.5 million, and organizes this research primarily through the Weber Research Institute. The New York State Center for Advanced Technology in Telecommunications, or the Institute for Imaging Sciences. Its educational and research programs enjoy considerable support from the electronics, computer and avionics industries located in New York Metropolitan region. Applications should be sent to Professor Henry L. Bertoni, Head, Electrical Engineering Department, Polytechnic University, 333 Jay Street, Brooklyn NY 11201. Equal Opportunity/Affirmative Action Employer. M/F/V/H.

Assistant Professor in Systems Science. Systems Science Department, State University of New York at Binghamton, invites applications for a tenure-track faculty position from candidates in the systems science field with diverse teaching capabilities and research interests. The Department has offered the M.S. and Ph.D. programs with specialization in Systems Science. Applicants should send vita, ■ statement of research interests, and should arrange that three letters of recommendation be sent to: Professor George J. Klir, Chair, Systems Science Dept., SUNY, Binghamton, NY 13902-6000. The State University of New York at Binghamton is strongly committed to affirmative action. We offer access to services and recruit students and employees without regard to race, color, sex, religion, age, disability, marital status, sexual orientation or national origin.

Chair in Photonic Systems. The Department of Electrical Engineering of McGill University is seeking an incumbent for a new Chair in Photonic Systems. Bell Northern Research and Northern Telecom Ltd., together with McGill University, will be seeking support for this Chair from the Natural Sciences and Engineering Research Council (NSERC) of Canada, through their Industrial Research Chair (IRC) program. Since this program is based on peer review, the successful candidate must be an internationally recognized authority, preferably working at the interface between photonic devices and systems, with outstanding scientific and leadership qualities that can bring the Department of Electrical Engineering to the forefront of research in Photonic Systems. An important condition for achieving this goal is the appointee's ability to build up a strong academic program for both graduate and undergraduate students. The position carries a highly competitive salary, junior faculty positions specifically designated in Photonic Systems, necessary laboratory space and, above all, strong University support for the above stated goals. Interested candidates are invited to send their resume to: Professor N.C. Rumin, Chairman, Department of Electrical Engineering, McGill University, 3480 University St., Montreal, QC, Canada, H3A 2A7. In accordance with Canadian Immigration requirements, this advertisement is directed in the first instance to Canadian citizens and Permanent residents of Canada. Applications from others are welcomed, however, consideration of their applications must be deferred until a Canadian search has been completed.

Douglas Strain Endowed Professorship and Head, Department of Applied Physics and Electrical Engineering, Oregon Graduate Institute of Science & Technology (OGI). The successful applicant must be ■ distinguished scientist who has attained international recognition in the broad area of semiconductor electronics, who has achieved a high level of research sponsorship for a sustained period, and who has achieved a high level of research sponsorship for a sustained period, and who has ■ strong commitment to excellence in graduate education. Primary emphasis will be placed on the overall excellence of the candidate. Specific research areas within semiconductor electronics are open (e.g., semiconductor materials and device physics, device and circuit processing, etc.). Individuals who can lead a major strengthening of the electrical engineering program of the department will receive preference. As a private, graduate-only institution, OGI is committed to graduate education and research of the highest quality. It offers M.S. and Ph.D. programs in five interdisciplinary academic departments dealing with the physical, chemical, biological, computational/ computer and engineering sciences. OGI is located in the Portland metropolitan area with easy access to the many cultural and recreational opportunities found in the Pacific Northwest. Nominations, applications (with complete CV), or requests for further information should be sent to Dr. James J. Huntzicker, Provost, Oregon Graduate Institute of Science & Technology, 19600 N.W. von Neumann Dr., Beaverton, OR 97006-1999. OGI is an Affirmative Action/Equal Opportunity Employer.

Engineering Mathematics and Computer Science Position. The School is seeking qualified individuals for engineering mathematics and computer science position, Assistant Professor, 12-month, tenure track starting the 1990-91 academic year. Requirements include Ph.D. with specialization in Computer Science or related Mathematical Modeling, Compiler Design, or formal Computer Science areas. Candidates having interests in closely related areas will be considered. Preference will be given to candidates with an engineering background. All applicants must be presently authorized to work on a full-time indefinite basis in the United States. Responsibilities include research and the teaching of graduate and undergraduate courses. Excellent computing facilities are available including DEC 8650 VAX with ■ VAX Cluster, 2 IBM 3090's with vector processor, Vision Systems, a Micro VAX cluster, graphics equipment, AI Symbolics and DEC workstations, a UNIX laboratory, and a variety of micro computer systems in local area network. The department offers Bachelor, Masters of Engineering Mathematics and Computer Science, and Ph.D. Degrees in Computer Science and Engineering. Expected start date is August 15, 1991, but applications should be received before February 15, 1991. Send application and resume to: Dr. Khaled A. Kamel, Chairman, Department of Engineering Mathematics and Computer Science, Speed Scientific School of Engineering, University of Louisville, Louisville, Kentucky 40292. Equal Opportunity/Affirmative Action Employer.

Assistant Professor—Residence. The University of Connecticut's Department of Electrical and Systems Engineering invites applications for ■ non-tenure track position of Assistant Professor in Residence. The successful candidate is expected to contribute to our nationally-recognized program in distributed decision making and man-machine systems. Duties are to develop and teach courses in decision theory and systems modeling, with emphasis on systems that contain humans as components; and to conduct laboratory research to collect and analyze data on the performance of multi-person teams to support analytic modeling efforts. Minimum qualifications include an earned Ph.D. in Decision Sciences, Systems Engineering, or ■ closely related technical field, plus experience in modeling human decision making problems. Ability to develop large-scale computer simulations of dynamical processes is also required. Additional desired qualifications include knowledge of software aspects of small local-area computer networks; experience with UNIX and C computer languages; and interest in assisting students in the learning process. The salary is $29,000. Submit application and resume to: Dr. David L. Kleinman, U-157, The University of Connecticut, Storrs, CT 06269-3157 by December 28, 1990. AA/ EOE. (Search #1A126).

The University of Michigan Department of Electrical Engineering and Computer Science. The Department of Electrical Engineering and Computer Science at The University of Michigan invites applications for positions at all levels in its Computer Science and Engineering Division. Our emphasis is on the areas of operating systems, distributed systems and networks, software engineering, programming languages, theoretical computer science, and database systems. Exceptional candidates in other areas of computer science and engineering will also be considered. All candidates who apply should have an interest in teaching and ■ strong research orientation. Send your resume and the names of at least three references to Professor Bernard A. Galler, Chair of the Faculty Search Committee, CSE Division, EECS Department, The University of Michigan, Ann Arbor, MI 48109-2122. The University of Michigan is an Equal Opportunity/Affirmative Action Employer.

Carnegie Mellon: The Departments of Engineering and Public Policy and Electrical and Computer Engineering have a joint tenure track position for teaching and research on technical and policy issues in telecommunications policy; information policy; electronic industrial policy; or international security policy. Require Ph.D. and demonstrated research skills. Require policy aptitude and prefer demonstrated skills. Resume with references and writing sample to Prof. M. Granger Morgan, Head, EPP, Carnegie Mellon University, Pittsburgh, PA 15213. EO/AA employer.

Senior Faculty Position in Electrical and Computer Engineering, State University of New York at Buffalo. Nominations are requested to fill an anticipated tenured senior faculty position, beginning August 1991. Candidates must have an earned doctorate, with teaching and research interests related to photonics, Computers or Communications Engineering. The successful candidate will have an opportunity to recommend new faculty and be provided with funds to establish a strong research and educational program. This position will involve undergraduate and graduate course development and teaching, coordination of a research program involving younger faculty, interaction with existing faculty and exploration of interdisciplinary areas of education and research. The Department has 31 faculty, 200 full-time graduate students, and 400 undergraduate students at the Junior and Senior level. Candidates should supply ■ resume with names and addresses of three or more individuals for letters of reference. Nominations may be sent to Professor Wayne A. Anderson, State University of New York at Buffalo, Department of Electrical and Computer Engineering, 201 Bell Hall, Buffalo, NY 14260. SUNY at Buffalo is an equal opportunity/affirmative action employer.

Auburn University—Earle C. Williams Eminent Scholar Chair in Electrical Engineering. Nominations and applications are invited for the Earle C. Williams Eminent Scholar Chair in Electrical Engineering. Candidates for this chair should have achieved national and international prominence in digital systems and/or microelectronics. Applicants or nominees must have an earned doctorate, senior academic experience, and a documented record of distinction in university teaching and research. The successful candidate will be expected to provide intellectual leadership in his/her area of expertise for the Department of Electrical Engineering as well as enrich the scholarly environment at Auburn University. Auburn University is located in the city of Auburn in east-cental Alabama. This land-grant univeristy

enrolls more than 21,000 students, the largest on-campus enrollment in the state. The Department of Electrical Engineering, one of eight departments within the College of Engineering, offers Bachelor, Master, Master of Science and Ph.D. degrees in Electrical Engineering. The department has a current enrollment of 939 undergraduate students and 100 graduate students. The 28 full-time faculty have an annual research expenditure of approximately $2 million. The Search Committee will begin its review of applications immediately. Interested candidates should submit: (1) ■ detailed resume, (2) a letter indicating an interest in the chair, the candidates's academic philosophy, and a brief statement of accomplishments in teaching and research, and (3) names and addresses of five references. Nominations should be submitted with the complete name, mailing address and telephone number of the individual nominated. Applications and nominations should be sent to Professor J. David Irwin, Department of Electrical Engineering, Auburn University, AL 36849-5201. Auburn University is an affirmative action/ equal opportunity employer. Applications from minority and female candidates are encouraged.

Concordia University—Department of Computer Science Tenure Track Positions. The Department of Computer Science, Concordia University, is seeking qualified candidates for tenure track faculty positions at all levels, in the areas of Programming Languages, Software Engineering, Expert Systems and Machine Intelligence. Applicants should have a Ph.D. degree in Computer Science or related field with a strong research record. Salary and benefits are attractive and negotiable. The Department currently has 26 full-time professors. It offers both undergraduate and graduate programs up to the Ph.D. level with an enrollment of over 1000 students. The language of instruction is English. The Department and the University have excellent research and teaching facilities, and support staff. Apply giving resume and the names of at least three references to: Dr. T.D. Bui, Chairman, Department of Computer Science, Concordia University, 1455 de Maisonneuve Blvd. West, Montreal, Quebec H3G 1M8, Canada. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Concordia University—Department of Computer Science. Applications are invited for Visiting Faculty, Post-Doctoral and Research Associate positions in the following areas: pattern recognition and machine intelligence, expert systems, databases, programming languages, software engineering, VLSI architecture, numerical analysis. Applicants should have a Ph.D. degree in computer science or related field with a good research record. The Department currently has 26 full-time professors. It offers both undergraduate and graduate programs up to the Ph.D. level with an enrollment of over 1000 students. The language of instruction is English. The Department and the University have excellent research and teaching facilities, and support staff. Apply giving resume and the names of at least three references to: Dr. T.D. Bui, Chair, Department of Computer Science, Concordia University, 1445 de Maisonneuve Blvd. West, Montreal, Quebec H3G 1M8 Canada. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

University of Minnesota, Duluth—Applications are invited for the Jack Rowe Professorship in Engineering at the rank of associate or full professor. Responsibilities: Develop curriculum toward ■ proposed degree in electrical engineering (50% teaching, 50% outreach and research). Qualifications: Doctorate in electrical engineering or related field plus a minimum of five years post-doctoral degree relevant teaching and/or industrial experience in the United States. Interest and expertise in power or control system engineering is particularly desirable. Demonstrated evidence of effective teaching and communication skills appropriate to a faculty member is required. Tenure possible in accordance with University regulations. Salary: Competitive. Beginning date of appointment: September 1, 1991. Applications must be received by February 1, 1991. Send to: Dr. Nazmi M. Shehadeh, Chair; Jack Rowe Professorship Search Committee; College of Science and Engineering; 140 Engineering Building; University of Minnesota, Duluth; Duluth MN 55812 (E mail: vwangens@ub.d.umn.edu). Only completed applications will be considered. A complete application consists of (1) letter of applications, (2) resume, (3) names, addresses, and phone numbers of three references. The Univeristy of Minnesota is an equal opportunity educator and employer and welcomes applications from women and minorities.

Electrical Engineering, University of Washington—Applications for tenure-track and research faculty positions are invited from highly qualified, research-oriented candidates in electrical engineering. Areas of special interest include: electromagnetics, including wave propagation and scattering, remote sensing, and fiber optics; communications systems, including applications of lightwave technology; fault-tolerant systems; electronic systems and design; photonics; or controls and robotics. Women and minority candidates are especially encouraged to apply. Send resume with four references to Prof. M.A. Afromowitz, Chairman of Faculty Search Committee, Department of Electrical Engineering FT-10, University of Washington, Seattle, WA 98195. The University of Washington is an equal opportunity/affirmative action employer.

Post Doctoral Fellowship: Department of Electrical and Computer Engineering, Ohio University, is seeking ■ Post Doctoral Research Associate in Bipolar VLSI Circuit Simulation. Salary range 20K to 24K US dollars for 12 months. Send resume and three letters of reference to: Dr. M. Ebrahim Mokari, Dept. ECE, Stocker Center, Ohio University, Athens, Ohio 45701. OU is an affirmative action/ equal opportunity employer.

San Diego State University (SDSU) invites applications for a tenure-track position in the Department of Electrical and Computer Engineering. The primary areas of interest are Control Systems and Power Systems. The position involves both research and teaching at the undergraduate and graduate levels. All levels of appointment will be considered. A Ph.D. in Electrical Engineering or ■ related field is required. SDSU is one of the largest Universities in California, offering over 150 different degrees. The ECE Department offers BS and MS degrees in Electrical Engineering, and has an enrollment of about 800 undergraduate and 150 graduate students. Send resume, by February 20, 1991 to Dr. L.R. Marino, Chair, Department of Electrical and Computer Engineering, San Diego State University, San Diego, California 92182-0190. San Diego State University is ■■ Equal Opportunity/Affirmative Action/Title IX employer.

University of Central Florida (UCF); The Electrical Engineering Department (32 Faculty, 820 undergraduates, 280 graduate students) has tenure/tenure-track openings in Communications, Digital Signal Processing, Digital/Analog Electronics, Electromagnetics, and Power, starting in the Fall of 1991. Rank and salary will be commensurate with qualifications. All applicants must have ■ Ph.D. at the time of employment and a strong commitment to teaching and research. Applications must be post-marked no later than February 1, 1991 and must be sent to: Dr. N.S. Tzannes, Chair, Electrical Engineering, University of Central Florida, Orlando, Florida 32816. UCF is ■■ equal opportunity/affirmative action employer. An an agency of the State of Florida, all application materials and selection procedures are available for public review.

Announcement—The Department of Electrical and Systems Engineering at Oakland University invites applications for a junior, tenure-track faculty position which involves both research and teaching of graduate and undergraduate courses. The primary areas of interest are Manufacturing Systems, Production Systems, Statistical Quality Control, and Engineering Management. Candidates must have an earned Ph.D. in engineering, an outstanding academic record and effective teaching ability. Located in southeastern Michigan, Oakland University is ■ state-assisted institution enrolling 12000 students. The Electrical and Systems Engineering undergraduate programs are ABET accredited; the departmental enrollment in the MS and Ph.D. programs is 140. Adjacent to campus is the 1100 acre Oakland Technology Park, one of the fastest growing parks in the U.S. Send ■ current resume, a statement concerning teaching and research interests, and a list of three references to: Professor Naim A. Kheir, Chairman, ESE Department, Oakland University, Rochester, Michigan 48309-4401. Deadline: February 22, 1991, or until a candidate is selected. Immigration status of non-United States citizens should be stated. Oakland University is an Equal Opportunity and Affirmative Action Employer.

Faculty Positions—Massachusetts Institute of Technology. The Department of Electrical Engineering and Computer Science seeks candidates for faculty positions starting in September 1991. We anticipate openings for several junior faculty appointments for individuals who are completing, or who have recently completed, a doctorate. Senior faculty positions may also be available in some areas. Faculty duties include teaching at both the graduate and undergraduate levels, research, and supervision of theses. We are interested in candidates in most areas of electrical engineering and computer science, such as artificial intelligence, communications, computer systems and languages, flexible manufacturing, and solid-state materials and devices. All candidates should write to the address below, describing their professional interests and goals. Applications should include a curriculum vitae and the names and addresses of three or more references. Additional material describing the applicant's work, such as papers or technical reports, would also be helpful. All candidates should indicate citizenship and, in the case of non-US citizens, describe their visa status. Send all applications to: Prof. F.C. Hennie, Room 38-435, Massachusetts Institute of Technology, Cambridge, MA 02139. M.I.T. is an equal opportunity/affirmative action employer.

Department of Electronic and Electrical Engineering, California Polytechnic State University, San Luis Obispo, invites applications for a full-time tenure-track position for Fall 1991. Ph.D. in Electronic, Electrical, or Computer Engineering required. Specialty in digital design desired. Industrial experience preferred. Anticipate one opening in computer engineering with design and laboratory emphasis. Emphasis on undergraduate education. Opportunity to participate in the development of a strong Master of Science degree program and a new B.S. Program in Computer Engineering. Rank and salary dependent on qualifications and experience. Send resume, three letters of reference, and official transcripts to Martin E. Kaliski, Chairman, Department of Electronic and Electrical Engineering, Cal Poly State University, San Luis Obispo, CA 93407. e-mail address: mkaliski@batman.elee.calpoly.edu. Tel. (805) 756-2781. FAX (805) 756-1458. Closing date: February 1, 1991 or until position is filled. Cal Poly is subject to all laws governing Affirmative Action and Equal Opportunity employment. All qualified persons, especially women and under represented minorities, are encouraged to apply.

The Electrical and Computer Engineering Department of Ecole Polytechnique de Montreal has an opening for a tenure-track assistant professor position. Duties: Participate in undergraduate and graduate teaching activities of either the electronics or the computer sections. Participate in the activities of the microelectronics research group and eventually develop her/his research areas. Participate in teaching of topics such as: electronics, microelectronics, computer architecture, operating systems computer graphics or software principles. Requirements: Possess a Ph.D. in one of the following areas: electrical engineering, computer science or computer engineering. He/ she should either be a member of the "Ordre des ingenieurs du Quebec" or be eligible. The candidate must be fluent in French, the teaching language at Polytechnique. Research experience in one of the following specialties in microelectronics is essential: design methods, verification, architectures, CAD tools, defect tolerances. An industrial experience would be an asset. Salary and conditions: The salary and social benefits are determined by the current Faculty collective agreement with the institution. Availability: The candidate should be available in March 1991. Applicants should send their resume before January 15, 1991 to: Direc-

teur, Department de genie electrique et de genie informatique, Ecole Polytechnique de Montreal, C.P. 6079, Succ. A, Montreal (QC), H3C 3A7 Canada, In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. Ecole Polytechnique is an equal opportunity employer.

Faculty Positions, Department of Electrical and Computer Engineering/ Syracuse University: Seeking regular faculty in the following areas of special interest: software engineering, the design of algorithms and software for parallel processing, parallel system performance evaluation, robotics and intelligent systems, vision systems and image processing, phototonics, and optical processing. Position may be filled at either an entry level or at experience levels. A doctorate in computer engineering, electrical engineering or a related area is required. Applicants should have a strong commitment to teaching at all levels and a dedication to research. Salary will depend on qualifications. The Department has a full-time faculty of 41 and offers graduate and undergraduate degree programs in both electrical engineering and computer engineering. Applications will be processed when received; deadline is March 1st or until the positions are filled. Send resumes with names, addresses and phone numbers of 4 references to: Professor Kamal Jabbour, Interim Chairman, Electrical & Computer Engineering Dept., 121 Link Hall, Syracuse University, Syracuse, NY 13244-1240. AA/EOE.

The George Washington University, Engineering Management, Tenure-Track Faculty Positions. Tenure-track faculty positions are available in the graduate program of the Department of Engineering Management, School of Engineering and Applied Science, starting Fall Semester 1991. Especially sought are applicants able to conduct research and teach in the areas of: 1) Environmental Management, Biotechnology Management, or Technology Assessment and Transfer. 2) Information Technology Management, Decision Support, Decision Analysis or Software Systems Engineering. 3) Project and Program Management and Total Quality Management. Candidates should have an earned doctorate in an engineering or applied science discipline and research experience with an interest in both teaching and research. Ability to attract funded research is valued. The George Washington University is located in the center of Washington, D.C. This metropolitan area sustains the second largest concentration of research and development activity in the United States, creating a continuing demand for rigorously trained engineers and many research opportunities. The Department of Engineering Management conducts major off-campus degree program at locations in the Washington metropolitan area and the candidates chosen for these positions will participate in these programs. Salary and entry level academic rank will be dependent upon qualifications. Applications will be reviewed beginning November 15 and will be accepted until the positions are filled. Send vita, publications list, and three reference to: Professor Homer B. Sewell, Chairman, Department of Engineering Management, School of Engineering and Applied Science, The George Washington University, Washington, DC 20052. The George Washington University is an Affirmative Action/ Equal Opportunity Employer.

Visiting Professorships, Research Faculty/Research Staff, School of Engineering and Applied Science, The George Washington University. Visiting Professorships, Research Faculty, and Research Staff Positions, at junior and senior levels, are available in the School of Engineering and Applied Science. The George Washington University starting Fall Semester 1991. The School of Engineering and Applied Science is organized into four academic departments: the Department of Civil, Mechanical and Environmental Engineering; the Department of Electrical Engineering and Computer Science; the Department of Engineering Management; and the Department of Operations Research. Candidates are especially sought to teach and/ or conduct research in the following areas: Aeronautics; Aerospace Engineering; Analog Electronics/VLSI; Astronautics; Biotechnology Management; Communications; Computational Fluid Dynamics; Computer Aided Design; Computer Engineering; Computer Graphics; Computer-Integrated Design and Manufacturing; Computer Science; Decision Analysis; Decision Support Systems; Electrical Engineering; Engineering Management; Environmental Management; Environmental Engineering; Finite Element and Mechanics; Geotechnical Engineering; Information Technology Management; Manufacturing/Production Management; Mathematical Optimization; Operations Research; Project and Program Management and Total Quality Management; Reliability; Robotics/Controls; Simulation; Software Systems Engineering; Stochastic Processes; Structural Engineering; Technology Assessment and Transfer; and User-Computer Interface. Appointments are for one-year periods. Applicants should send vita, including complete publication list, and three reference to: Visiting Engineers Scholars Program or Research Faculty and Staff Program, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052. The George Washington University is an Affirmative Action/ Equal Opportunity Employer.

Two Research Assistant Professorships. Seek candidates for non-tenure leading roles starting in January to plan, organize and carry out research in ellipsometric evaluation of film thicknesses and optical properties of materials; take and interpret photoreflectance and photothermal spectra for semiconductors and related materials; conduct real time insitu optical measurements at extremes of temperature, and publish results in scholarly journals. Requires Ph.D. in Electrical Engineering or Solid State Physics; one year post Doctoral experience in optics and materials research. Must have demonstrated ability to set up, align and calibrate experimental optical systems; conduct optical properties evaluation utilizing spectroscopic ellipsometry and reflectance spectra; set up and operate ultra high vacuum systems, and do real time optical measurements at temperature extremes. Requires publication record of scholarly articles in referred journals. Salary commensurate with qualifications and experience. Remit vita, cover letter, representative publications, and names, addresses and telephone numbers of three references to: Search Chair, Center for Microelectronic and Optical Material Research, 209-N Walter Scott Engineering Center, University of Nebraska-Lincoln, Lincoln, Nebraska 68588-0511. (402) 472-1975. Affirmative Action/ Equal Opportunity Employer.

Professor/Microelectronic Research Laboratory Director—The Department of Electrical and Computer Engineering at Rutgers University is seeking candidates for appointment at the full Professor level (or higher) for an individual who will also be qualified for appointment as Director of the Microelectronics Research Laboratory (MERL). The MERL Director is expected to assume a leadership role in the Microelectronics group and to affect the research directions of the new Microelectronics facility. In addition he/ she should be able to enlist the support of industry and government for the support of the facility. The position is available immediately as ■ complete clean room facility is currently coming on-line. The clean area is ca 3,500 ft2 class 1,000/100 locally. Separate areas are equipped for: Photolithography, Wet etching, Dry processing and for Oxidations, Diffusion, LPCVD and Ion Implantation. Material and Device characterization currently exists outside the Microelectronics Laboratory area, but an additional characterization area will be brought up for the needs of the fabrication facility. There are currently five faculty members in MERL, in addition to ■ Chief Engineer/Operations Manager and a Technician. Interested individuals please contact Dr. B. Lalevic, Department of Electrical and Computer Engineering, Rutgers University, P.O. Box 909, Piscataway, NJ 08855-0909. Telephone (908) 932-3871, Fax: -5313. Rutgers, The State University of New Jersey, is an Affirmative Action/Equal Opportunity Employer.

The Department of Electrical Engineering of Arizona State University is seeking faculty members at the full professor level who will play a leading role in the future development of the department and who will support department activities in either the Center for Solid State Electronics, the Telecommunications Center, the Center for Systems Science and Engineering or the Electric Power Research Laboratory. Applicants should currently be leading major research programs with significant external funding and have substantial experience in teaching at both the graduate and undergraduate levels. Applicants must have an earned doctorate degree in Electrical Engineering or a related discipline. Arizona State University the U.S.'s fifth largest university with more than 43,000 students, 12,000 of whom are graduate students. The Electrical Engineering Department has approximately 480 graduate and 900 undergraduate students, and research expenditures of $3.5M per year. The University has both a Cray XMP-18/SE and IBM 3090-500/MV computers, and these are supplemented by the Center for Solid State Electronics Research's Convex C-1's and Ardent Titan graphics machines. Please send letters of application, resumes and the names of three references to: Dr. David Ferry, Chairman, Department of Electrical Engineering, Arizona State University, Tempe, AZ 85287-5706. The first deadline is January 31, 1991, or the 15th of each month until position is filled. Arizona State University is an equal opportunity, affirmative action employer.

Electromagnetics: The Department of Electrical Engineering of Arizona State University is seeking a tenure-track faculty member at the assistant professor level in the general area of electromagnetics. This faculty member will be involved in graduate and undergraduate instruction and research. Applicants must have an earned doctorate in the field of Electrical Engineering, with expertise in one or more of the following: antennas, microwaves, scattering, or radar. The successful applicant will be affiliated with the Telecommunications Research Center, a center for research excellence. Arizona State University is the U.S.'s fifth largest university with more than 43,000 students, 12,000 of whom are graduate students. The Electrical Engineering Department has approximately 480 graduate and 900 undergraduate students, and research expenditures of $3.5M per year. The University has both ■ Cray XMP-18/SE and an IBM 3090-500/MV computer, and these are supplemented by the Center for Solid State Electronics Research's Convex C-1's and Ardent Titan graphics machines. The Department also has a large electromagnetic anechoic chamber along with a compact range. Please send letters of applications, resumes, and the names of three references to: Dr. David K. Ferry, Chairman, Department of Electrical Engineering, Arizona State University, Tempe, AZ 85287-5706. The first deadline is January 31, 1991, or the 15th of each month until position is filled. Arizona State University is an equal opportunity, affirmative action employer.

The Department of Electrical Engineering at Arizona State University is seeking an assistant professor in the area of Solid State Electronics. This faculty member will provide leadership in research, as well as graduate and undergraduate instruction. Applicants must have an earned doctorate in the field of Electrical Engineering or a related discipline, with expertise in either optoelectronics, semiconductor crystal growth, nanoelectronic modeling and fabrication, semiconductor processing, automated semiconductor manufacturing, analog/digital or VLSI circuits and architectures. Other complimentary research areas may also be considered. The successful applicant will be affiliated with the Center for Solid State Electronics Research, a center of research excellence. The center consists of 29 faculty members and 120 graduate students who occupy 40,000 square feet of laboratory and office space including ■ 4,000 square foot class-100 clean room. The Electrical Engineering Department has approximately 450 graduate and 900 undergraduate students, and research expenditures of $3.5M per year. The university has both a Cray XMP-18/ SE and IBM 3090-500 MV computers and these are supplemented by the Center for Solid State Electronic Research Convex C-1's. Please send letters of application, resumes and the names of three references to: Dr. David Ferry, Chairman, Department of Electrical Engineering, Arizona State University, Tempe, AZ 85287-5706. The first deadline is January 31, 1991, or the 15th of each month until position is filled. Arizona State University is an equal opportunity, affirmative action employer.

Shared Mathematics Department Professorship with Boise State University and Hewlett-Packard Company, Boise, Idaho. Boise State University, in cooperation with Hewlett-Packard, invites applicants for a tenure-track position in the Department of Mathematics for the school year beginning in the Fall of 1991. Applicants should have a Ph.D. in Computer Science, or a related field, with preference given

to candidates with expertise in software engineering, artificial intelligence, or database systems. Industry experience is beneficial. Responsibilities will include teaching, research, and service to be split at both the University and at Hewlett-Packard's Boise site. Salary will be commensurate with level and qualifications. Boise, Idaho's largest city, offers city living in the heart of the scenic outdoors, and is the site of many technology-based corporations. Those interested should send a completed letter of application, ■ vita, three letters of reference and graduate transcripts to: Dr. Phillip Eastman, Computer Science Committee Chair, College of the Arts and Sciences, Boise State University, Boise, Idaho 83725. Boise State University and Hewlett-Packard Company are EEO/AA employers. Screening will begin January 15, 1991.

Department of Physics and Engineering Science, University of Michigan-Flint invites applications for a tenure-track Assistant Professorship in Engineering Science starting September 1991. Applicants must have a Ph.D. in engineering, be committed to excellence in teaching, be prepared to initiate ■ research program that can involve undergraduate students and should have teaching experience. Primary research area: manufacturing and robotics, including mechanical, electrical and software components. Interdisciplinary approach in research and teaching is sought. The successful candidate will possess skills in design, project direction, and general engineering, would teach existing mechanical and/or electrical courses, and develop courses in robotics, simulation, and finite element analysis. Position subject to funding constraints. UM-Flint is an urban, nonresidential campus enrolling 6,500 students. The programs in Engineering Science are B.S. programs in general engineering. The Program maintains excellent relations with local industry, including co-op and employment opportunities for students, and opportunities for university/industry research. Applications, including a current resume, names of four references, a letter indicating research projects contemplated and a philosophy of teaching should be sent to Prof. R.K. Gupta, Dept. of Physics & Engineering Science, University of Michigan-Flint, Flint, MI 48502-2186 (313/762-3131). Screening of applications will begin on January 3, 1991, with final deadline for receipt of January 31, 1991. UM-Flint is an equal opportunity/affirmative action employer. Minority and women candidates are encouraged to apply.

University of California, Davis Faculty Positions in Electrical Engineering and Computer Science. The Department of Electrical Engineering and Computer Science at UC Davis invites applications for various tenure track positions. The primary areas of interest are Computer Engineering and Microprocessor Application; Electronic Circuits; Image Processing and Computer Vision; and Optoelectronics. One position in the area of image processing and one in the area of optoelectronics. One position in the area of image processing and one in the area of optoelectronics is open to all ranks. Other positions are at the assistant professor level. The department, with 53 faculty members and 180 full-time graduate students, is experiencing rapid growth. Our College is the nation's sixteenth largest producer of engineering Ph.D.'s in a University which has the nineteenth largest extramural research funding. Salary and benefits are extremely attractive. Davis is a pleasant, family-oriented community near Sacramento, within easy driving distance to Silicon Valley, the Lawrence Livermore National Laboratory, San Francisco, the Pacific Ocean, and the Sierra Nevada Mountains. We are seeking individuals with strong records of teaching and research and with ambitious plans. Senior appointments require outstanding records of achievement; junior appointments must show evidence of great promise. All faculty are expected to have a strong commitment to teaching at all degree levels, and to demonstrate the ability to attract significant research support. The positions require a Ph.D. or equivalent, and are open until filled; but in order to assure consideration, applications should be received by March 1, 1991. Send ■ resume and the names of at least three references to: Professor S. Louis Hakimi, Chair, Attention: Faculty Search Committee, Department of Electrical Engineering and Computer Science, University of California, Davis, CA 95616. The University of California, Davis, is an equal opportunity/affirmative action employer.

Tennessee Technological University, Department of Electrical Engineering, invites applications for ■ tenure-track faculty position. The individual's primary emphasis should be in VLSI design with a strong background in electronics and digital systems. Three state-supported Centers of Excellence within the College provide a strong incentive for research. Candidates must have ■ Ph.D. in a relevant area and have abilities and interest in teaching at the undergraduate and graduate levels as well as conducting externally funded research in their area. Rank is negotiable but preference will be given to assistant professor. Screening process will begin February 15, 1991 and continue until filled. Submit resume and three references to Dr. G.M. Molen, Chairman, Electrical Engineering Department, Tennessee Technological University, Cookeville, TN 38505. TTU is an affirmative action/equal opportunity/TitleIX/Rehabilitation Act of 1973 employer.

Department Head Engineering. The Colorado School of Mines, ■ select public institution for science and engineering education, is seeking candidates for the position of Head of the Department of Engineering. This department offers ■ non-traditional -Bachelor of Science degree in Engineering, with concentrations in mechanical, electrical and civil engineering, and is in the process of expanding its graduate program in interdisciplinary engineering. The successful candidate should possess ■ Ph.D. in engineering. Applicants with a minimum of five (5) years of industrial , academic, or other pertinent management experience, ■ mature research record, and the ability to maintain and foster excellence in the undergraduate program while broadening graduate and research activities will be given preference. The responsibilities of the department head include the administration of ■ faculty of approximately 24 members, the preservation of quality teaching standards, the representation of the department on campus and to industry and government agencies, and the development of sponsored research and an expanded fiscal and resource base. Applications will be considered until such time ■■ a suitable candidate is selected which is anticipated to be prior to the start of the 1991-92 academic year. Resumes and supporting documents, including the names and addresses of three references should be submitted to: Colorado School of Mines, Engineering Department Head Search Committee, PO Box 69, Golden, CO 80402. An Equal Employment Opportunity/Affirmative Action Employer. Minorities and Females Encourage to Apply.

The Purdue University School of Engineering and Technology at Indianapolis invites applications for several anticipated tenure-track positions at the Assistant/Associate Professor level in the areas of Computer Engineering and Signal Processing. Specific interests are in the areas of Medical Image Processing, Digital Signal Processing and Neural Networks, Robotics and Intelligent Machines with Vision and Sensor Applications, Communications Systems and Software Engineering. Applicants must hold an earned Ph.D. in Electrical Engineering or Computer Engineering. The positions offer unique opportunities to develop new capabilities in the areas mentioned and require a strong Commitment to teaching at the graduate and undergraduate levels and to the development of sponsored research. The School is currently developing interdisciplinary research efforts with the Indiana University School of Medicine, the second largest medical school in the country. Rank and salary are highly competitive and based upon experience and qualifications. Send resume with names an addresses of three references by January 31, 1991 to: Dr. A.S.C.Sinha, Acting Chairman, Department of Electrical Engineering, Purdue University School of Engineering and Technology at Indianapolis, 1201 East 38th Street, AD 157, Indianapolis, IN 46205-2868. The School of Engineering and Technology is one of the sixteen (16) schools of Indiana University-Purdue University at Indianapolis (IUPUI). IUPUI has an enrollment of over 28,500 students and 140 academic programs. The School of Engineering and Technology is an equal opportunity/affirmative action employer.

Biomedical Engineer: Works directly with other biomedical researchers. Develops, designs and implements fuzzy controllers and expert systems. Develops fuzzy control theory and other theoretical basis. Authors or coauthors research papers. B.S. in Biomedical Engineering and 5 yrs. experience required in: developing fuzzy control theory and implementing its applications in medicine; designing and implementing fuzzy blood pressure and blood oxygen control systems and expert systems, cardiac/surgical ICU setting. Published papers on fuzzy controllers in medicine in national journals. Salary to $40,032. Apply at the Texas Employment Commission, Galveston, Texas or send resume to the Texas Employment Commission, TEC Building, Austin, Texas 78778, J.O.#6122722. Ad paid by an Equal Employment Opportunity Employer.

Electrical Engineering: The University of Dayton invites applications for a tenure-track position at the assistant or associate professor level. The Department of Electrical Engineering is seeking an individual who will have an earned doctorate by the contract start date to teach and perform research in the general area of signal processing with capabilities in one of the following areas: communication systems, control systems and VLSI circuits. The department currently offers degrees through the doctorate with approximately 400 undergraduates and 100 graduate students. The University of Dayton is situated in a dynamic, high technology area where there is a wide range of cultural and professional activities. U.S. Citizenship or permanent residency is preferred. Salary and starting date are negotiable with the latest starting date begining August 16, 1991. Send vita and the names and addresses of three references to : Dr. Don Moon, Chairman, EE Dept., University of Dayton, 300 College Park Drive, Dayton, OH 45469-0226. UD is an EEO/AA employer.

University of California at Berkeley—Faculty Positions In Control, Communications, and Low-Temperature Electronics, effective Fall Semester 1991, pending budgetary approval. The Department of Electrical Engineering and Computer Sciences at the University of California at Berkeley is currently seeking outstanding faculty candidates with research in the general areas of: (i) Nonconventional Computation for Control Systems. Areas of interest are application-specific computation systems where conventional computational techniques are inadequate such as encountered in large dynamical optimization problems, large computer aided control systems design problems, distributed real-time control systems or event driven dynamical systems. Candidates will be expected to teach undergraduate and graduate courses in the areas of linear and nonlinear control, optimization. (ii) Communication Systems. Areas of special interest include spread spectrum techniques, radio networks, personal and cellular networks and optical networks. Candidates will be expected to teach undergraduate and graduate courses in communication theory and estimation. (iii) Superconductive Electronics. Candidates might have interests in superconducting digital circuit design and/or device and fabrication technology for low and high-temperature superconductors. Candidates will be expected to teach undergraduate and graduate courses in semiconducting or superconducting devices, technology and/or circuits. Appointments will only be made at the Assistant Professor level in ■ tenure-track position. An applicant must have ■ doctoral degree or comparable academic and industrial experience. Interested persons should apply as soon as possible and by February 28, 1991, to the Chairman at the address listed below, including a resume, copies of publications, a statement of interest, and names and addresses of references. Candidates who applied earlier for positions (i) or (iii) should write reaffirming their interest, and may update their application, if desired. Professor Paul Gray, Chairman, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California 94720. Telephone: (415) 642-0253. The University of California is an Equal Opportunity, Affirmative Action Employer.

The University of Kentucky invites applications for three tenure-track faculty positions in the Graduate Center for Biomedical Engineering.

Areas of interest include signal/ image processing, control theory, instrumentation, biomechanics, and biomaterials. The candidates should have an on-going research program and a strong interest in teaching at the graduate level. Rank and salary are commensurate with experience. Applicants should submit ■ detailed curriculum vita with the names addresses of at least three references to: Search Committee, Center for Biomedical Engineering, Wenner Gren Research Laboratory, University of Kentucky, Lexington, KY 40506-0070. The deadline for applications is March 1, 1991.

Drexel University. The Department of Electrical and Computer Engineering expects to have openings for tenure-track and visiting faculty during the academic year 1991/1992. At the present time we are seeking individuals with strong interest in engineering education and academic research, whose areas of specialization belong to one of the following: Computer Engineering (cellular automata, systolic arrays and fault-tolerant computing), Power Electronics and Power devices, Industrial Control and Microwave/Lightwave Engineering (devices, fiber optics and integrated optics). Applicants must have a Ph.D. The department graduated about 220 BS, 60 MS, and 15 Ph.D. students in 1990 and has active groups in the areas of System Theory, Computer Engineering, Power Systems and Electrophysics. Send Curriculum Vitae, including references, to Dr. Bruce A. Eisenstein, Head, Department of Electrical and Computer Engineering, Drexel University, Philadelphia, PA 19104. Immigration status of non-US citizens should be stated. Drexel University is an equal opportunity/ affirmative action employer, and welcomes applications from women and minorities.

The University of Michigan-Chairperson, Aerospace Engineering. The Department of Aerospace Engineering at the University of Michigan invites applications and nominations for the position of Department Chairperson. The candidate should hold a Ph.D. degree in Aerospace Engineering or a related discipline and be ■ nationally recognized leader in education and research. Submit supporting materials, including resume and names of references, to: Dr. Elmer G. Gilbert, Chair of Search Committee, Department of Aerospace Engineering, The University of Michigan, Ann Arbor, MI 48109-2140. The University of Michigan is an equal opportunity, affirmative action employer.

SUNY Stony Brook—The Department of Electrical Engineering, SUNY Stony Brook invites applications for anticipated openings for all professor ranks. These positions will be tenure track with salary negotiable. The Department has undergraduate and graduate programs and extensive research activities. The areas of prime interest are computer engineering, digital systems, machine vision, VLSI design, and robotics. The Department has extensive computing facilities. Applicants in other areas will be considered. The Department has close relations with high technology industry. Stony Brook combines the attraction of semi-rural location with proximity to the resources of the New York City area. Please submit resume to: Prof. Kenneth L. Short, Chairman, Department of Electrical Engineering, SUNY Stony Brook, Stony Brook, NY 11794-2350. SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK 174

Government/Industry Positions Open

Director of Research and Development. Initiate and supervise fiber optics and optoelectronics research & development activities; conduct research on lasers, detectors and optoelectronic integrated circuits; develop fiber related components; oversee marketing functions and financing. Ph.D. in Electrical or Electronic Engineering. 3 years research in fiber optics and/ or optoelectronic technology. Research experience must include electronic and optoelectronic device concept and design, mask design, device characterization and processing, high speed circuits, and multifunctional, resonance tunneling and LED devices; academic coursework in applied electronics, electronics and communications, optoelectronic device, lasers and applications, silicon devices, integrated circuit design, and microelectronic devices. $60,000/yr; 40hrs/wk. Place of employment and interview: Santa Clara, CA. If offered employment, must show legal right to work. Clip ad and send with resume to: Job No. BLW17981, P.O. Box 9560, Sacramento, CA 95823-0560 not later than 12/31/90.

Electrical Designer required by expanding Indi- ■ A/E office. Qualified individual should have degree and 3-4 yrs. of progressive experience in the comprehensive design of power distribution and lighting systems associated with commercial and institutional projects; but, we will also consider a non-degreed person with 5-7 yrs. similar experience. Ability to assume key project respon. and communicate effectively is also essential. Firm offers excellent compensation and long term future in ■ stable environment and attractive living community. Please contact our reps in confidence at: G. Marshal Assoc.—P.O. Box 66083—Chicago. IL 60666.

Engineer Electrical—Principal Electrical Engineer. Glumac & Associates, Inc. is an established consulting engineering firm with offices in: Portland, Oregon; San Francisco, Sacramento, & Los Angeles, California; and Madrid, Spain. Offering services in Mechanical, Electrical, Acoustical and Energy Engineering. Glumac specializes in high rise offices buildings, high-tech facilities, hospitals, and institutional projects. The Portland, Oregon office of Glumac has an opening for ■ Principal Electrical Engineer. The ideal candidate will have a minimum of 15 years experience, be proficient at hands on design, & have excellent communication ■ management skills. Please respond with resume & salary requirements to: Glumac & Associates, Inc., 920 S.W. Third Avenue, Suite 100, Portland, Oregon 97204.

Managing Engineer, Electrical Instrument Clusters. To manage engineering department; supervise work of engineers, designers, drafters; liaison with Japanese parent, subsidiaries and customers; direct & control design, testing & development of auto instrument clusters; responsible for product maintenance, establishing draft/engineer standards, assignments to contract detailers. Require Bachelor of Electrical Engineering plus minimum five years experience in design & engineering of electrical automotive instrument clusters at managerial level. Must speak, read and write Japanese. 40 hr/wk 8-5 M-F $975/wk Send resumes to 7310 Woodward Avenue, Room 415, Detroit, MI 48202 Ref. No. 63390. Employer paid ad.

Research Physicist/Electrical Engineer/Chief Scientist. In collaboration with the Engineering Director, identify, evaluate and recommend Technological/Scientific developments necessary to sustain the Company's objective of preeminence in current products applicable to Magnetic Resonance Imaging and Spectroscopy (MRI/MRS) as well as to research spectrometers involving Electron Paramagnetic Resonance (EPR/ESR) and Nuclear Magnetic Resonance (NMR). Requires ■ Ph.D. or equivalent in EE or Physics. This position requires scientific liason with gov't., university and medical college research activities as well as the monitoring of technical/scientific society meetings and journals. Also, this position will actively direct the preparation of SBIR proposals and function ■ a Principal Investigator on Contracts which have the potential to develop new business opportunities with ■ science-based competitive advantage. We offer competitive salary, benefits and moving allowances together with a performance bonus. Send resume to Medical Advances, Inc. P.O. Box 26425, Milwaukee, WI 53226-0425, Attention: J.Cameron.

Maintenance Electrical Engineer for NE Ohio hotel/motel chain to perform circuit analysis, control device evaluation, error analysis, & test AC/DC measurement of existing and new equipment; review and study data recorded concerning operation condition & temperatures for more than 1,000 individual air conditioning & heating units, 10 central units, & 15 boilers; make recommendations to maximize efficiency, reliability & durability of systems, in regular status reports to company president; oversee operation & maintenance of systems; determine optimal manual and computerized control adjustments; supervise installation of systems; design & update circuits. No exp. req. in above duties but applicants may qualify with a B.S. in Electrical Engineering [must have taken at lease 4 courses in circuits (including 1 course in electronic circuits), 2 in control, & 1 course ea. in computer logic, random signals, and system simulation]. Must be willing to drive to 9 hotels in Ohio, Texas, Tennessee and Illinois for up to one month at a time, at least once a yr. for each hotel—employer will pay mileage and provide a room for travel to hotels; must provide own car. 40 hrs/wk. Mon.-Thurs. 7AM-4:30PM; Fri. and Sat. alternating every other week, 7AM-4:30PM on call in emergency. $35,340/yr. Must have proof of legal authority to work permanently in U.S. Send resume in duplicate (no calls) to J. Davies, JO#1266812, Ohio Bureau of Employment Services, PO Box 1618, Columbus, Ohio 43216.

Lernout & Hauspie Speechproducts n.v., a Belgium based company specializing in R&D and manufacturing of multilingual voice I/O toolkits and application generators combining speech coding, speech synthesis and voice/ speech recognition on one board, is looking for an Electrical and/ or Computer Science Engineer or Ph.D. Apart from his/her scientific achievement, the successful candidate should prove his/her ability in transferring research results into commercial products. The candidate will be assisted by other experts in the field from within the company as well as from external university labs. An Expert In Programming Signal Processing Applications On DSP'S (TMS320C25, TMS320C30 and/or Motorola 56000) may also add his extensive experience in the field to our speech processing know-how. Your application will be considered thoroughly but with discretion. Please send your application letter and career profile to the following address: Lernout & Hauspie Speechproducts n.v. Attn: Mr. Herve Bourlard, Koning Albert 1 laan 64, B-1810 Wemmel/ Brussels*, Belgium. Tel. 32.2.460.33.97 Fax.32.2.460.01.72 Private tel. 32.71.51.25.95. (*) If you apply after October 1st, the postal code for Wemmmel/Brussels will be 1780.

Computer Engineer for NE Ohio Biomedical Instrument Sensors manufacturer to design circuits (analog & digital) for computers; develop microprocessor (Intel Series) interface; design Real-Time microprocessor (Intel Series) system & control system; design software using Intel Assembler, Quick-Basic, & C language; develop digital, analog, & biomedical signal processing; design Real-Time adaptive & feed-back control system; design & apply data acquisition. No exp. necessary in above duties but applicants may qualify with 2 years exp. as an Electronics Design Engineer (exp. must be in design of analog ■ digital circuits & development of microprocessor (Intel) system control interface). M.S. degree in Electrical Engineering required with coursework including at least 1 course each in Advanced Switching & Logic, Digital Signal Processing, Computer Physics, Advanced Microprocessor System Design (with lab), & Adaptive Control. M-F 8:00AM-5:00PM. $37,145/yr. Must have proof of legal authority to work permanently in U.S. Send resume in duplicate (No Calls) to J. Davies, JO# 1255620, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216.

Engineer/Senior Engineer: Career opportunity with a publicity-owned water and power utility located in Southern California. B.S. Degree in Electrical Engineering and five years' experience in one or more of the following, plus registration as Electrical Engineer in the state of California or ability to become registered within one year. Design of protective relays for power systems, including substations, transmission lines and generation stations. Design and construction of transmission line structures and preparation of bid specifications. Design and installation of electrical controls and equipment for generation stations, including hydro, steam and combustion turbines. Design and installation of microwave systems, UHF and VHF bands, telephone systems and equipment, both analog and digital, and supervisory/ administrative controls. Salary range from $3586 to $5563 per month commensurate with experience, Send resume or contact Imperial Irrigation District, Personnel Department, 1284 Main Street, El Centro, California 92243. Telephone number (619) 339-0620. Cite this ad in response. Each inquiry will be treated confidentially. An equal opportunity employer.

Scientific Programmer—Position available to research, design & code optimal power flow, transient & steady state stability analysis, & short circuit analysis algorithms for large-scale computer systems that monitor & control the transmission of electric power. Must have MS

degree in electrical engineering, with research in the area of optimal power flow, transient & steady state stability analysis, & short circuit analysis on large scale real-time power systems plus at least 5 years applied research experience with either an electric utility or research institute in the same areas, developing functional algorithms encoded in FORTRAN Must be ■ U.S. citizen or permanent resident. Salary $3900/month. Send resume to : S. Springmeyer, #1-03, Minnesota Department of Jobs & Training, 390 No. Robert St. Room 124, St. Paul, Minnesota, MN 55101. Affirmative Action Employer.

Scientific Programmer—Position available to research & design mathematical algorithms that perform power systems security analysis & state estimation on real-time computer systems that monitor & control the transmission of electric power. Must have Ph.D. degree in electrical engineering, with research in real-time state estimation, security analysis, & transient stability of large-scale power systems. Also must have at least 5 years experience with either ■ vendor of computerized power systems controls or an electric utility, developing large-scale power systems security analysis, unit commitment & optimal power flow algorithms encoded in Fortran. Must be ■ U.S. citizen or permanent resident. Salary $4250/month. Send resume to: to S. Springmeyer, #0-221, Minnesota Department of Jobs & Training, 390 No. Robert St., Room 124, St. Paul, MN 55101. Affirmative Action Employer.

Engineer, Senior Design (Project Leader). Design system & arch. for 495 cache controller on Intel 486 microprocessors; simulate trace-driver of 486 memory hierarchy; design circuit for 495; VLSI layout for 495; design DSP chip set; develop image data compression system; supervise projects. Ph.D. in EE or CS + 3 yrs. exp. in job offered or in engineering req'd. Must have exp. in system & arch. design, image processing, data compression algorithms, C UNIX programming & neural network tech. Must also know VLSI layout, CAD tools (GDT, VHDL, SPICE), micron silicon fab. $5000/mo. Job site/interview: Santa Clara, CA. Send ad with resume to Job # MD-19193, P.O. Box 9560, Sacramento, CA 95823-0560, no later than 1-1-91.

Real time system engineer needed. Designs real time electronic hardware which must be incorporated into ■ real time computer system which monitors turbomachinery. Writes software at various levels to incorporate hardware with sensors and computer systems. Assists clients in the field to evaluate, interpret vibration data for turbomachinery. Write system documentation in Spanish, provide operational manuals for user in Spanish. Travel to client sites in South America, Europe and Asia to install systems. Teaches users in the field to operate and calibrate systems. Conducts seminars in English and Spanish at company headquarters to instruct client operational personnel in use, operation of system. Applicant must have B.S. or foreign equivalent in electrical or electronic engineering; 1 year experience or 1 year experience in related engineering; experience must include at least one years's experience working with turbomachinery. Must have knowledge of real time operating systems. Must speak ■ Spanish and be able to write technical reports in Spanish. Require foreign travel-at least 30% of time. 40 hrs./wk. $28,000/yr. Applicants contact Texas Employment Commission, Houston, Texas, J.O. #5424769. Ad Paid by Equal Opportunity Employer.

Senior Design Engineer For Roanoke VA Emp. Resp. for power conversion design eng involving the design of state of the art power conv equip including design and packaging of power bridges for solid state power conversion for use with control elec to provide variable controls for AC and DC motors incl lab eval of elec perf & heat dissipation; des, const & validation of prototypes. Must have M.S. or equiv in Elec Eng w/ 7 yrs exp in power conv des eng and knowledge of AC-DC & DC-AC power conversion; perf reqs in paper, metals, mining and material handling inds; operation, diagnostics and interaction of digital regulating systems with large power converters & ind power systems & analysis techs inc harmonics, reactive power, fault calc & protection. Comp langs—assembly, C, BASIC, prof in use of digital storage oscilloscope and digital and analog chart recorder. 40 hrs/wk Hrs 8:00-4:45, $71,100/yr, no OT. To apply: mail or and carry RES w/copy of ad attach to: VEC, Department 3008, 1202 Franklin Rd, Roanoke, VA 24002-0061, JO#VA9032113. EEOE.

Clinical Engineer: Will coordinate a preventive maintenance and repair program for designated biomedical equipment in accordance with current legal and accreditation standards. Will coordinate and control incoming inspection of biomedical equipment including direction and technical input of new system installation as well ■■ documentation and tagging system implementation. Will troubleshoot equipment and dilemma and cause and solution of any hazard problems. Will evaluate new equipment including analysis of safety and proper equipment utilization. Requires Master's degree in Clinical Engineering. Education to include completion of one course in each of the following: Biomedical Instrumentation; Applied Electronics for Biomedical Engineering; Clinical Behavioral Science in Management; and, Hospital Management. Hours: 9:00 a.m.—5:00 p.m. 40 hours per week at $634.80 per week salary. Please send resume to : Illinois Department of Employment Security, 401 South State Street—3 South, Chicago, Illinois 60605, Attention: Leon Donegan, Reference #V-IL 1901-D, No Calls, An Employer Paid Ad.

Engineer, Electrical Engineering Research: Research in signal processing & speech engineering. Develop speaker-independent continuous speech recognition system, using advanced signal processing technique & stochastic theory. Basic research for new speech analysis methods; stochastic modeling of phonetic units; speaker adaptation & system optimization. Must have either Ph.D./Electrical Engineering or M.S./E.E. + 4 years experience. Must have previous research in speech engineering & signal processing & automatic speech recognition, including theories of: advanced signal processing, advanced pattern recognition; optimization; advanced stochastic & phoneme-based stochastic modeling of speech signal. Salary: $4400/month; job & interview: Santa Barbara, CA. Send this ad & resume to: JOB #CC18740, P.O. Box 9560, Sacramento, CA 95823-0560 by December 31, 1990.

A limited number of Postdoctoral Fellowship positions will be available in the fall of 1991 for research in ocean engineering. Research areas include engineering mechanics, marine materials, robotics, electrical and optical engineering. Deadline for application is 1 April 1991. Specify area of interest with request for information brochure and application packet from: Kathy Morton, Postdoctoral Program, Harbor Branch Institution, Inc., 5600 Old Dixie Highway, Fort Pierce, Florida 34946. An Equal Opportunity Employer.

Engineer, Senior Design Engineer. Conduct modeling, parameter extraction, simulation and algorithm development for photolithography systems; apply processes to state-of-the-art VLSI semiconductor manufacturing. Ph.D. in Electrical Engineering. Academic project/ research background in photolithography optical characterization and measurement, semiconductor device design, characterization, layout and modeling, low temperature device characterization, MOS measurement and analysis and interface studies; also academic coursework in optics spectroscopy, solid state devices, IC fabrication and computer architecture and design. $4,500/mo; 40 hrs./wk. Place of employment and interview: Santa Clara, CA. If offered employment, must show legal right to work. Clip ad and send with resume to: Job No. DN 18763, P.O. Box 9560, Sacramento, CA 95823-0560 not later than December 31, 1990. The company is an equal opportunity employer and fully supports affirmative action practices.

Engineer, Electronics Engineer (Senior CAD): Develop CAD system for design, simulation and modeling of VLSI circuits; conduct architecture planning, algorithm development, system integration, and coding, testing, documentation and benchmarking of VLSI CAD software programs; develop design methodologies and train designers in CAD tools application. Ph.D. in Computer/ Electrical Engineering. Academic project/research background in CAD and VLSI design, including logic design and layout, performance verification, algorithm implementation for CAD placement and routing system, numerical simulation, circuit and layout routers and UNIX, C, Assembly, Makefile and osh; also academic coursework/background in computational geometry, graph theory and CAD system architecture $4,546/mo; 40 hrs./wk. Place of employment and interview; Santa Clara, CA. If offered employment, must show legal right to work. Clip ad and send with resume to: Job No. BLW19241, P.O. Box 9560, Sacramento, CA 95823-0560 not later than December 31, 1990. The company is an equal opportunity employer and fully supports affirmative action practices.

Sr. Principal Electronic Engineer—Antenna Systems: Lead major projects and make unique individual technical contributions to the research & development of Antenna Systems (HF through Microwave). Perform research, staff and consulting assignments requiring highly diversified knowledge in computer modeling to predict the behavior of complex physical structures to Electromagnetic fields using advanced numerical methods and test performance predictions. Requires degree in Physics or EE (Ph.D. preferred) and 7-12 years experience to include significant work in Antenna Systems, Digital Signal Processing and Electromagnetics. U.S. citizenship may be required. Send resumes to Staffing Programs, Attn: 0007LH, Lockheed Sanders, Inc., P.O. Box 2029, Nashua, NH 03061. An equal opportunity/ affirmative action employer.

The Food and Agriculture Organization of the United Nations (FAO) invites applications for the post of Maintenance Officer at its Headquarters in Rome, Italy. Responsibilities: To coordinate the maintenance and running of operations of electrical and mechanical installations in FAO office buildings. Qualifications: University degree in electromechanical engineering. Five years' professional experience as an engineer, with particular experience in the maintenance and upkeep of electrical and mechanical installations in large office buildings. Working knowledge of English, French or Spanish and working knowledge of Italian. Leadership qualities; ability to solve problems quickly and tactfully; ability to work in harmony with people of different national and cultural backgrounds. Willingness to use word-processing equipment. Benefits: Relocation, tax-free salary, cost of living adjustment, education grant and other benefits of the International Civil Service. Please send detailed curriculum vitae not later than December 1990 quoting VA 928-AFS to Central Recruitment, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

Electrical Engineer for NE Ohio real estate development firm to design, manufacture & test electrical component equipment & systems on site; consult on manufacture, construction, installation & operational testing to ensure conformance of equipment & systems with functional specifications & requirements; design electrical components & equipment to efficiently utilize electrical energy for commercial & industrial properties; design solar cell compenents & equipment to efficiently utilize photovoltaic effect for commercial & industrial properties through the use of semiconductor theory in placement of amorphous solar cells & state of the art solar cells. No exp. reg. Must have Bachelor's degree in Electrical Engineering (must have taken 1 course ea. in solar cell theory, photovoltaic systems, & semiconductor development theory). M-F 8:00AM-5:00PM. $27,930/yr. Must have proof of legal authority to work permanently in U.S. Send resume *in duplicate* (No Calls) to J. Davies, JO# 1255625, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

IEEE Spectrum Annual Index
Volume 27, 1990

This index covers all technical items — papers, correspondence, reviews, etc. — that appeared in this periodical during 1990, and items from previous years that [illegible] commented upon or corrected in 1990.

The *Author Index* contains the primary entry for each item, listed under the first author's name, and cross-references from all coauthors. The *Subject Index* contains several entries for each item under appropriate subject headings, and subject cross-references.

It is always necessary to refer to the primary entry in the *Author Index* for the exact title, coauthors, and comments/corrections.

AUTHOR INDEX

A

Adair, Eleanor R. Speakout—Nurturing electrophobia; *SPEC Aug 90* 11, 14

Adam, John A., and Karl Esch. Technology '90: Aerospace and military; *SPEC Jan 90* 49-51. *Includes Expert Opinion section* by S. H. Durrani

Adam, John A. A die-hard engineer in the White House; *SPEC Mar 90* 24-26
Comments by Keller, D. M., *SPEC Aug 90* 18

Adam, John A. Competing in a global economy; *SPEC Apr 90* 20-24

Adam, John A. The right kind of accidental career; *SPEC Jul 90* 44-45

Adam, John A. Industries transcend national boundaries; *SPEC Sep 90* 26-31

Adam, John A. Federal laboratories meet the marketplace; *SPEC Oct 90* 39-44

Adam, John A. Defense: Toward smaller, more deployable forces, [illegible] lethal as can be; *SPEC Nov 90* 30-33

Albertson, Vernon D., *see* Kappenman, John G., *SPEC Mar 90* 27-33

Alexander, K. Mark, *see* Lathrop, Richard H., *SPEC Apr 90* 41-42

Armstrong, Alan. Comments on 'Bracing for the geomagnetic storms' by J. G. Kappenman and V. D. Albertson; *SPEC Jul 90* [illegible] (Original article, Mar 90 27-33)

Aspray, William. The stored program concept; *SPEC Sep 90* 51

B

Baker, Louis. Comments on 'Computer-aided fighter pilots' by W. B. Rouse et al.; *SPEC Nov 90* 14 (Original article, Mar 90 38-41)

Baker, M. H. Comments on 'Power and energy' by G. Zorpette; *SPEC Oct 90* 6 (Original item, Jun 90 28-30)

Barker, Anthony T. Comments [illegible] 'Technology '90: Medical electronics' by K. Fitzgerald; *SPEC Aug 90* 18 (Original article, Jan 90 52-54)

Barnett, Robert D. The frequency that wouldn't die; *SPEC Nov 90* 120-121

Barry, Robert. Paying for R&D (Ltr.); *SPEC Dec 90* 22

Baum, Dwight C. Comments on 'The bombsight [illegible] Norden vs. Sperry' by L. Searle; *SPEC Mar 90* 16 (Original article, Sep 89 60-64)

Bell, Trudy E. Technology '90: The main event; *SPEC Jan 90* 28-29

Bell, Trudy E. Applications '90: Telecommunications; *SPEC Feb 90* 31-33. *Includes Expert Opinion section* by J. S. Ryan

Bell, Trudy E., and Karl Esch. Correction to 'The space shuttle: A case of subjective engineering' (Jun 89 42-46); *SPEC Mar 90* 16

Bell, Trudy E. Corrections to 'Applications '90: Telecommunications' (Feb 90 31-33); *SPEC Apr 90* 31-33

Bell, Trudy E. Light that acts like 'natural bits'; *SPEC Aug 90* 56-57

Bell, Trudy E. Technical challenges to a decentralized phone system; *SPEC Sep 90* 32-37

Bell, Trudy E. From monopoly to competition: Long-term research is vulnerable; *SPEC Oct 90* 46-50

Bell, Trudy E. Just keeping current entails ingenuity, resourcefulness, and improvisation; *SPEC Oct 90* 69-73

Bell, Trudy E. '90s employment: Some bad news, but some good; *SPEC Dec 90* 32-43

Ben-Yaacov, Giora, *see* Hoffman, Steve, *SPEC Dec 90* 53-56

Bobbs, Bradley. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 6 (Original item, Apr 90 19)

Breslyn, William E. The rule of the roads (Ltr.); *SPEC Apr 90* 6

Brittain, James E. Thévenin's theorem; *SPEC Mar 90* 42
Comments by Ryder, J. D., and Stockman, H. E., *SPEC Nov 90* 14

C

Campanella, S. Joseph. Communications satellites: Orbiting into the '90s; *SPEC Aug 90* 49-52

Campbell, Graham M., *see* Morreale, Patricia A., *SPEC May 90* 40-42

Cates, Ron. Gallium arsenide finds [illegible] new niche; *SPEC Apr 90* 25-28

Cates, Ron, Max J. Helix, and Kenneth V. Rosseau. Review of 'Gallium Arsenide Digital Integrated Circuit Design' (Long, S. and Butner, S.; 1990); *SPEC Nov 90* 11-12

Cendes, Zoltan J. EM simulators = CAE tools; *SPEC Nov 90* 73-77, 93

Chen, Katherine T., *see* Santo, Brian, *SPEC Jan 90* 41-43

Chen, Katherine T. Applications '90: Soviet optoelectronics; *SPEC Feb 90* 44-45

Chen, Katherine T. Applications '90: The specialties; *SPEC Feb 90* 46-47

Chen, Katherine T., and Glenn Zorpette. Electrotechnology: '92 and beyond: Microelectronics and computers; *SPEC Jun 90* 32-33

Chen, Katherine T. Continental challenges: The single-market engineer; *SPEC Jun 90* 47-49
Comments by de Bruyn, R., *SPEC Nov 90* 14

Chen, Katherine T. A canny manager of Boeing's electronics R&D; *SPEC Sep 90* 44-45

Chen, Katherine T. Harnessing university research for competitiveness, industry support; *SPEC Oct 90* 73-76

Chen, Katherine T. Contrasting strategies are pursued by big three economic powerhouses; *SPEC Oct 90* 76-78

Chen, Katherine T. Reversing sagging precollege skills in mathematics and science; *SPEC Dec 90* 44-48

Christiansen, Donald. Spectral Lines—Medical costs; *SPEC Jan 90* 25

Christiansen, Donald. Spectral Lines—Science and Engineering; *SPEC Feb 90* 21

Christiansen, Donald. Spectral Lines—'Easy' money; *SPEC Feb 90* 21

Christiansen, Donald. Spectral Lines—Goodbye, inch; *SPEC Mar 90* 23
Comments by Hillinger, D., Wheeler, H. A., Vannucci, G., and King, H. E., *SPEC Jun 90* 8; Gould, R. G., Eckert, J. K., and Harral, B. D., *SPEC Aug 90* 6

Christiansen, Donald. Spectral Lines—In praise of checklists; *SPEC Mar 90* 23

Christiansen, Donald. Spectral Lines—Reader feedback; *SPEC Mar 90* 23

Christiansen, Donald. Spectral Lines—Who said 'user friendly'?; *SPEC Apr 90* 19

Christiansen, Donald. Spectral Lines—Ethical judgment; *SPEC Apr 90* 19
Comments by Donahue, E. L., FitzSimmons, L., Bobbs, B., Emery, J. T., Perstein, M. H., Rothstein, J., and Turner, B., *SPEC Aug 90* 6, 18

Christiansen, Donald. Spectral Lines—Telephone trials and triumphs; *SPEC May 90* 27

Christiansen, Donald. Spectral Lines—Shoreham slumbers; *SPEC May 90* 27

Christiansen, Donald. Spectral Lines—Europe gets ready; *SPEC Jun 90* 19

Christiansen, Donald. Spectral Lines—On elegant design; *SPEC Jun 90* 19

Christiansen, Donald. Spectral Lines—NASA goofed again; *SPEC Jul 90* 17

Christiansen, Donald. Spectral Lines—Ethics [illegible] revisited; *SPEC Jul 90* 17

Christiansen, Donald. Spectral Lines—Kudos; *SPEC Aug 90* 21

Christiansen, Donald. Spectral Lines—Education/generation gap; *SPEC Aug 90* 21

Christiansen, Donald. Spectral Lines—Fading loyalty; *SPEC Aug 90* 21

Christiansen, Donald. Spectral Lines—Secrecy [illegible] its price; *SPEC Sep 90* 25

Christiansen, Donald. Spectral Lines—R&D notes; *SPEC Oct 90* 25

Christiansen, Donald. Spectral Lines—Open questions on defense; *SPEC Nov 90* 29

Christiansen, Donald. Spectral Lines—It's the law; *SPEC Nov 90* 29

Christiansen, Donald. Spectral Lines—Instant cachet; *SPEC Dec 90* 31

Christiansen, Donald. Spectral Lines—College ($) woes; *SPEC Dec 90* 31

Chrysler, Mack. Canon: More than just cameras; *SPEC Nov 90* 113-116

Courtney, Robert H., Jr. Review of 'The Cuckoo's Egg' (Stoll, C.; 1989); *SPEC Aug 90* 15-16

D

Dallas, William J. A digital prescription for X-ray overload; *SPEC Apr 90* 33-36
Comments by Thompson, I., *SPEC Dec 90* 22

Daskal, Steven E. Speakout—Real-world aircraft requirements: B-1 vs. B-2; *SPEC Feb 90* 8

de Bruyn, R. Comments on 'The single-market engineer' by Chen, K. T.; *SPEC Nov 90* 14 (Original article, Jun 90 47-49)

Desoer, Charles A. Comments, with reply, on 'Electromagnetic fields: The jury's still out—I: Biological effects' by I. Nair and M. G. Morgan; *SPEC Dec 90* 16, 22 (Original article, Aug 90 23-27)

Dodington, Sven. Review of 'Radar Development to 1945' (Burns, R., *Ed.*; 1989); *SPEC Jun 90* 12-13

Donahue, Eugene L. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 6 (Original item, Apr 90 19)

Dorn, Philip H. Comments on 'Of mice and menus: Designing the user-friendly interface' by T. S. Perry and J. Voelcker; *SPEC Jan 90* 6 (Original article, Sep 89 46-51)

Draving, Steve, [illegible] Rush, Ken, *SPEC Sep 90* 38-39

Duffy, Gavan, [illegible] Lathrop, Richard H., *SPEC Apr 90* 41-42

E

Eckert, Jeffrey K. Comments [illegible] 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Aug 90* 6 (Original item, Mar 90 23)

Eldon, Charles A. Wescon (Ltr.); *SPEC Jul 90* 8

Emery, James T. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 6 (Original item, Apr 90 19)

Esch, Karl, [illegible] Adam, John A., *SPEC Jan 90* 49-51

Esch, Karl, [illegible] Bell, Trudy E., *SPEC Mar 90* 16

Esch, Karl. Electrotechnology: '92 and beyond: Aerospace and defense; *SPEC Jun 90* 30-32
Estell, Robert G. Watching the swing of the pendulum (Ltr.); *SPEC Mar 90* 16
Eurich, John P., and Gene Roth. EDIF grows up; *SPEC Nov 90* 68-72

F

Fields, Craig. Review of 'America's Struggle for Leadership in Technology' (Derain, J.-C.; 1990); *SPEC Dec* [illegible] 11-12
Finn, Bernard. A continent bound by wire; *SPEC Aug 90* 58-59
Fisher, Charles. Comments on 'Bracing for the geomagnetic storms' by J. G. Kappenman and V. D. Albertson; *SPEC Jun 90* [illegible] (Original article, Mar 90 27-33)
Fitzgerald, Karen. Technology '90: Medical electronics; *SPEC Jan 90* 52-54. *Includes Expert Opinion section* by C. F. Walker
Comments by Barker, A. T., *SPEC Aug. 90* 18
Fitzgerald, Karen. Correction to 'Technology in medicine: Too much too soon?' (Dec 89 24-29); *SPEC Feb 90* 6
Fitzgerald, Karen. Applications '90: Instrumentation; *SPEC Feb 90* 37-38. *Includes Expert Opinion section* by M. S. P. Lucas
Fitzgerald, Karen. Correction to 'Technology in medicine: Too much too soon?' (Dec 89 24-29); *SPEC Mar 90* 16
Fitzgerald, Karen. Shoreham in repose; *SPEC May 90* 46-48
Fitzgerald, Karen. Continental challenges: Global standards; *SPEC Jun 90* 44-46
Fitzgerald, Karen. Electromagnetic fields: The jury's still out (Special report intro.); *SPEC Aug 90* 22
Fitzgerald, Karen. Electromagnetic fields: The jury's still out—2: Societal reverberations; *SPEC Aug 90* 27-32
Fitzgerald, Karen. Contract research gains adherents for its flexibility and low overhead; *SPEC Oct 90* 58-60
Fitzgerald, Karen. Encouraging risk-taking, sanctioning failures are helping spur creativity; *SPEC Oct 90* 67-69
Fitzgerald, Karen. Whistleblowing: Not always a losing game; *SPEC Dec 90* 49-52
FitzSimmons, Larry. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* [illegible] (Original item, Apr 90 19)
Flory, [illegible]. The great blue box phone frauds; *SPEC Nov 90* 117-119
Formwalt, John M. Waste not, want not (Ltr.); *SPEC Feb 90* [illegible]
Frey, Walter W. Speakout—Educating dyslexic engineers; *SPEC Dec 90* 6

G

Gabriel, Kaigham J., *see* Howe, Roger T., *SPEC Jul 90* 29-31, 34-35
Gabrynowicz, Joanne Irene. Review of 'Breakout into Space: Mission for a Generation' (Elias, G. H.; 1990); *SPEC Sep 90* 12-13
Geddes, Norman D., *see* Rouse, William B., *SPEC Mar 90* 38-41
Gilmour, Peter S., *see* Vaglica, John J., *SPEC Nov 90* 106-109
Goeller, Lee. Thoughts on HDTV (Ltr.); *SPEC Sep 90* 11
Goldman, Jack E. Review of 'The Managerial Mystique: Restoring Leadership in Business' (Zaleznik, A.; 1989); *SPEC Oct 90* 16
Goodwin, Nancy C. Comments, with reply, on 'Toward [illegible] compatible human–computer interfaces' by R. S. Nickerson and R. W. Pew; *SPEC Oct 90* 6 (Original article, Jul 90 40-43)
Gould, Richard G. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Aug* [illegible] 6 (Original item, Mar 90 23)
Greenwood, Ronald G. Review of 'Rust to Riches: The Coming of the Second Industrial Revolution' (Rutledge, J., and Allen, D.; 1989); *SPEC Jul 90* 12-13
Gunny, E. R. Tracking TCAS (Ltr.); *SPEC Jul 90* 8
Guterl, Fred. Continental challenges: Tradeoffs: Turf vs. togetherness; *SPEC Jun 90* 36-38,43
Guterl, Fred. Siemens profile; *SPEC Dec 90* 57-60

H

Hale, Leslie C. Sky–earth capacitive coupling (Ltr.); *SPEC May 90* 11
Hall, Robert J., [illegible] Lathrop, Richard H., *SPEC Apr 90* 41-42
Hamer, Howard. Turn on, tune up (Ltr.); *SPEC May 90* 11
Hammer, John M., *see* Rouse, William B., *SPEC Mar 90* 38-41
Harral, Brian D. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Aug 90* 6 (Original item, Mar [illegible] 23)
Headrick, James M. Looking over the horizon; *SPEC Jul 90* 36-39
Heilmeier, George H. Review of 'The Chip War: The Battle for the World of Tomorrow' (Warhofsky, F. C.; 1989); *SPEC Apr 90* 15-16
Heisman, [illegible]. Speakout—Why good engineers sometimes 'fail'; *SPEC Oct 90* 11, 14
Helix, Max J., *see* Cates, Ron, *SPEC Nov 90* 11-12
Hillger, Don. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Jun 90* 8 (Original item, Mar [illegible] 23)
Hines, John [illegible]. Affordable analog design; *SPEC Nov 90* 60, 62, 64, 66-67, 93
Hoffman, Steve, Giora Ben-Yaacov, and Alfred Rosenblatt. Software 'workstations': One-stop shopping for utilities; *SPEC Dec 90* 53-56
Howe, Roger T., Richard S. Muller, Kaigham J. Gabriel, and William S. N. Trimmer. Silicon micromechanics: Sensors and actuators [illegible] chip; *SPEC Jul 90* 29-31, 34-35

I

Itoh, Noboru. New tricks for [illegible] old power source; *SPEC Sep 90* 40-43

J

Johnson, Robert R. Multichip modules: Next-generation packages; *SPEC Mar 90* 34-36, 46, 48
Jurgen, Ronald K. Technology '90 (Special issue intro.); *SPEC Jan 90* 26
Jurgen, Ronald K. Applications '90 (Special issue intro.); *SPEC Feb 90* 22
Jurgen, Ronald K. Applications '90: Consumer electronics; *SPEC Feb 90* 39-41. *Includes Expert Opinion section* by J. E. Carnes
Jurgen, Ronald [illegible]. Friendly adversaries help U.S. companies; *SPEC May 90* 50-51, 54
Jurgen, Ronald K. View from the top: Responding to the business divisions' needs; *SPEC Oct 90* 34-39
Jurgen, Ronald [illegible]. Global R&D for [illegible] 21st century manufacturing system; *SPEC Nov 90* 122-124
Jurgen, Ronald [illegible]. Putting electronics to work in the 1991 car models; *SPEC Dec 90* 72-75

K

Kanade, Takeo, [illegible] Whittaker, William L., *SPEC Dec 90* 64-67
Kaplan, Gadi. Applications '90: Industrial electronics; *SPEC Feb 90* 42-43. *Includes Expert Opinion section* by P. Gold
Kaplan, Gadi. Europower '92: EC '92: Status report; *SPEC Jun 90* 22-24
Kaplan, Gadi, and Alfred Rosenblatt. The expanding world of R&D; *SPEC Oct 90* 28-33
Kaplan, Gadi. Special guide to software systems, packages, and applications (Special report intro.); *SPEC Nov* [illegible] 47
Kaplan, Gadi. Keithley's phantom repeater: Applying wartime technology; *SPEC Dec 90* 71
Kappenman, John G., and Vernon D. Albertson. Bracing for the geomagnetic storms; *SPEC Mar 90* 27-33
Comments by Fisher, C., *SPEC Jun 90* 8
Comments by Armstrong, A., *SPEC Jul 90* 8
Kawada, Tsutomu, [illegible] Mori, Kenichi, *SPEC Aug 90* 46-48
Keller, Donald [illegible]. Comments on 'A die-hard engineer in the White House' by J. A. Adam; *SPEC Aug 90* 18 (Original article, Mar 90 24-26)
Kerley, John, *see* Rush, Ken, *SPEC Sep 90* 38-39
Kim, Wan Hee. Review of 'Is Korea The Next Japan?' (Kang, T. W.; 1989); *SPEC Mar 90* 12-13
King, Howard E. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Jun 90* 8 (Original item, Mar 90 23)
Kirk, Robert S., *see* Lathrop, Richard H., *SPEC Apr 90* 41-42

L

Langmuir, R., and D. Rutledge. Comments [illegible] 'Electromagnetic fields: The jury's still out—I: Biological effects' by I. Nair and M. G. Morgan; *SPEC Dec 90* 16 (Original article, Aug 90 23-27)
Lathrop, [illegible] H., Robert J. Hall, Gavan Duffy, K. Mark Alexander, and Robert S. Kirk. 'Functional abstraction' anticipates timing glitches; *SPEC Apr 90* 41-42
Lawrence, Charles [illegible]. Speakout—Global warming: A plethora of options; *SPEC Apr 90* 8
Lee, Richard. Software Reviews—RS/1; *SPEC Jul 90* 14
Levin, Gilbert V. Review of 'Mars Beckons' (Wilford, J. N.; 1990); *SPEC Dec 90* 11
Lipsett, Laurence, *see* Youst, David B., *SPEC Sep 90* 46-47
Longstaff, Fred M. Comments on 'Of mice and menus: Designing the user-friendly interface' by T. S. Perry and J. Voelcker; *SPEC Jan 90* 6 (Original article, Sep 89 46-51)
Lucky, Robert W. Reflections—The information filter; *SPEC Jan 90* [illegible]
Lucky, Robert W. Reflections—An EE in the land of Lilliput; *SPEC Mar 90* 6
Lucky, [illegible] W. Reflections—Feedback; *SPEC May 90* 8
Lucky, Robert W. Reflections—The electronic hobbyist; *SPEC Jul 90* 6
Comments by Zelby, L. W., *SPEC Sep 90* 11
Lucky, Robert [illegible]. Reflections—Not ready for prime time; *SPEC Sep 90* 6
Lucky, Robert W. Reflections—What's going on?; *SPEC Nov 90* 6

M

Martzloff, François. Protecting computer systems against power transients; *SPEC Apr 90* 37-40
Comment by Stewart, I. A., *SPEC Dec 90* 16
Masuoka, Fujio. Are you ready for next-generation dynamic RAM chips?; *SPEC Nov 90* 110-112
Mather, Bruce C. Needed DSP software emerges; *SPEC Nov 90* 52, 54, 57-59, 93
Meltzer, Irv. Comments on 'The bombsight war: Norden vs. Sperry' by L. Searle; *SPEC Mar 90* 16 (Original article, Sep 89 60-64)
Miller, Joel. Legal Aspects—Software copyright protection extended; *SPEC Nov 90* 18
Milstein, Laurence B., *see* Schilling, Donald L., *SPEC Aug 90* 40-41, 44-45
Morgan, M. Granger, *see* Nair, Indira, *SPEC Aug 90* 23-27
Morgan, M. Granger, and Indira Nair. Electromagnetic fields: The jury's still out—3 Managing the risks; *SPEC Aug 90* 32-35
Mori, Kenichi, and Tsutomu Kawada. From kana to kanji: Word processing in Japan; *SPEC Aug 90* 46-48
Morreale, Patricia A., and Graham M. Campbell. Metropolitan-area networks; *SPEC May 90* 40-42
Muller, Richard S., *see* Howe, Roger T., *SPEC Jul 90* 29-31, 34-35
Murphy, Erin E., and John Voelcker. Technology '90: Systems software; *SPEC Jan 90* 38-40. *Includes Expert Opinion section* by T. G. Lewis. *Correction, Feb. 90* 6

Murphy, Erin E. Technology '90: Transportation; *SPEC Jan 90* 47-48. *Includes Expert Opinion section* by A. Daniels
Murphy, Erin E., and John Voelcker. Correction to 'Technology '90: Systems software' (Jan 90 38-40); *SPEC Feb 90* 6
Murphy, Erin E. Applications '90: Design tools; *SPEC Feb 90* 34-36. *Includes Expert Opinion section* by P. W. Oman
Murphy, Erin E. Correction to 'Aging aircraft: Too old to fly?' (Jun 89 28-31); *SPEC Mar 90* 16
Murphy, Erin E. Reconciling conflicting design-automation standards; *SPEC Mar 90* 44-45
Murphy, Erin E. Electrotechnology: '92 and beyond: Transportation; *SPEC Jun 90* 26-28
Murphy, Erin E. The major players: Coming attractions: The Eastern bloc; *SPEC Jun 90* 53-54
Murphy, Erin E. Software R&D: From an art to a science; *SPEC Oct 90* 44-46
Murphy, Erin E., *see* Perry, Tekla S., *SPEC Oct 90* 79-82

N

Nair, Indira, and M. Granger Morgan. Electromagnetic fields: The jury's still out—1: Biological effects; *SPEC Aug 90* 23-27
Comments by Williams, S. B., Langmuir, R., Rutledge, D., and DeSoer, C. A., *SPEC Dec 90* 16
Nair, Indira, *see* Morgan, M. Granger, *SPEC Aug 90* 32-35
Nelson, David A. EC '92 (Ltr.); *SPEC Oct 90* 6, 18
Nickerson, Raymond S., and Richard W. Pew. Toward more compatible human–computer interfaces; *SPEC Jul 90* 40-43
Comments by Goodwin, N. C., *SPEC Oct 90* 6

P

Penzias, Arno. Speakout—Technology demands people orientation; *SPEC Jun 90* 11
Perry, Tekla S. Biomechanically engineered athletes; *SPEC Apr 90* 43-44
Perry, Tekla S. He builds tools for designers; *SPEC May 90* 44-45
Perry, Tekla S. Electrotechnology: '92 and beyond: Consumer electronics; *SPEC Jun 90* 33-34
Perry, Tekla S. Outlook: What executives think; *SPEC Jun 90* 57-60
Perry, Tekla S. Telephone challenges: A plethora of services; *SPEC Jul 90* 25-28. *Correction, Aug 90* 18
Perry, Tekla S. When East meets West; *SPEC Aug 90* 53-55
Perry, Tekla S. Teamwork plus technology cuts development time; *SPEC Oct 90* 61-67
Perry, Tekla S., and Erin E. Murphy. A shifting world balance of R&D power; *SPEC Oct 90* 79-82
Perry, Tekla S. Power engineering's powerhouse; *SPEC Dec 90* 61-63
Perstein, Millard H. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 18 (Original item, Apr 90 19)
Pew, Richard W., Nickerson, Raymond S., *SPEC Jul 90* 40-43
Pickholtz, Raymond L., *see* Schilling, Donald L., *SPEC Aug 90* 40-41, 44-45
Platts, George F. Comments on 'Speakout—Partnership and a professional revival' by D. Lundstrom; *SPEC Jan 90* 6 (Original item, Oct 89 12)
Pohlmann, Ken C. Review of 'Elements of Computer Music' (Moore, F. R.; 1990); *SPEC Oct 90* 16, 18

R

Raymond, Richard C. The 'threat of peace' (Ltr.); *SPEC Feb 90* 6
Richter, Henry L. Stop, in the name of law (Ltr.); *SPEC Jan 90* 6
Rosenblatt, Alfred, Kaplan, Gadi, *SPEC Oct 90* 28-33
Rosenblatt, Alfred. Defense: Expert observers: Defining national technology options; *SPEC Nov 90* 37-41
Rosenblatt, Alfred, *see* Hoffman, Steve, *SPEC Dec 90* 53-56
Rosseau, Kenneth V., Cates, Ron, *SPEC Nov 90* 11-12
Roth, Gene, Eurich, John P., *SPEC Nov 90* 68-72
Rothstein, Jerome. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 18 (Original item, Apr 90 19)
Rouse, William B., Norman D. Geddes, and John M. Hammer. Computer-aided fighter pilots; *SPEC Mar 90* 38-41
Comments by Baker, L., *SPEC Nov 90* 14
Ruggiero, Angelo. Comments on 'The bombsight war: Norden vs. Sperry' by L. Searle; *SPEC Feb 90* 6 (Original article, Sep 89 60-64)
Rush, Ken, Steve Draving, and John Kerley. Characterizing high-speed oscilloscopes; *SPEC Sep 90* 38-39
Rutledge, D., *see* Langmuir, R., *SPEC Dec 90* 16
Ryder, John D. Comments on 'Thévenin's theorem' by Brittain, J. E.; *SPEC Nov 90* 14 (Original article, Mar 90 42)

S

Saffo, Paul. Review of 'Megamistakes: Forecasting and the Myth of Rapid Technological Change' (Schnaars, S. P.; 1989); *SPEC Feb 90* 17-18
Saffo, Paul. Review of 'Shared Minds: The New Technologies of Collaboration' (Schrage, M.; 1990); *SPEC Nov 90* 11
Saito, Tadao. Japan telecommunications at the crossroads; *SPEC Nov 90* 126-128
Santalesa, Richard L. Software Review—Matlab; *SPEC Jan 90* 16
Santo, Brian, and Katherine T. Chen. Technology '90: Solid State; *SPEC Jan 90* 41-43. *Includes Expert Opinion section* by C. R. Barrett
Santori, Michael. An instrument that isn't really; *SPEC Aug 90* 36-39
Schilling, Donald L., Raymond L. Pickholtz, and Laurence B. Milstein. Spread spectrum goes commercial; *SPEC Aug 90* 40-41, 44-45
Self, Kevin. Designing with fuzzy logic; *SPEC Nov 90* 42-44, 105
Shaw, Robert E. Review of 'Mind Children: The Future of Robot and Human Intelligence' (Moravec, H.; 1988); *SPEC Jan 90* 12-13
Somberg, Howard. Comments on 'Technology '90: Power and energy' by G. Zorpette; *SPEC Apr 90* (Original article, Jan 90 44-46)
Spectrum staff. The case for CASE tools; *SPEC Nov 90* 78-81
Spectrum staff. Board tools proliferate; *SPEC Nov 90* 82-85
Spectrum staff. Displaying processed data; *SPEC Nov* 86-89
Spectrum staff. User-friendly CAE; *SPEC Nov 90* 90-92
Stallman, Richard. Comments on 'The quest for intruder-proof security systems' by K. Fitzgerald; *SPEC Feb 90* 6 (Original article, Aug 89 22-26)
Stein, Dale F. Review of 'Cold Fusion: The Making of a Scientific Controversy' (Peat, F. D.; 1990); *SPEC Sep 90* 13-14
Stewart, Ian A. Comments, with reply, on 'Protecting computer systems against power transients' by F. Martzloff; *SPEC Dec 90* 16 (Original article, Apr 90 37-40)
Stix, Gary. Technology '90: Data communications; *SPEC Jan 90* 35-37. *Includes Expert Opinion section* by C. L. Desmond
Stix, Gary. Big issues for the '90s; *SPEC Feb 90* 48
Stix, Gary. Electrotechnology: '92 and beyond: Telecommunications; *SPEC Jun 90* 25-26
Stix, Gary. The major players: Americans in Paris...; *SPEC Jun 90* 55-56
Stix, Gary, Zorpette, Glenn, *SPEC Jul 90* 18-23
Stix, Gary, *see* Zorpette, Glenn, *SPEC Jul 90* 23-24,
Stockman, Harry E. Comments on 'Thévenin's theorem' by Brittain, J. E.; *SPEC Nov 90* 14 (Original article, Mar 90 42)
Suran, Jerome J. A view from the other side; *SPEC Sep 90* 52-54

T

Thompson, Ian. Comments, with reply, on 'A digital prescription for X-ray overload' by W. J. Dallas; *SPEC Dec 90* 22 (Original article, Apr 90 33-36)
Torrero, Edward A. R&D—Managing to be competitive in a global context (Special issue intro.); *SPEC Oct 90* 26-27
Trimmer, William S. N., Howe, Roger T., *SPEC Jul 90* 29-31, 34-35
Turner, Bruce. Comments on 'Spectral Lines—Ethical judgment' by D. Christiansen; *SPEC Aug 90* 18 (Original item, Apr 90 19)

V

Vaglica, John J., and Peter S. Gilmour. How select a microcontroller; *SPEC Nov 90* 106-109
Vannucci, Giovanni. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Jun 90* (Original item, Mar 90 23)
Vendelin, George D. Evaluating nonlinear models for microwave GaAsFETs; *SPEC Sep 90* 48-50
Vesperman, Gary. The 'threat of peace' (Ltr.); *SPEC Feb 90* 6
Voelcker, John, Murphy, Erin E., *SPEC Jan 90* 38-40
Voelcker, John, *see* Murphy, Erin E., *SPEC Feb 90* 6
Voelcker, John. Applications '90: PCs and workstations; *SPEC Feb 90* 24-27. *Includes Expert Opinion section* by S. R. Ruth
Voelcker, John. Applications '90: Peripherals; *SPEC Feb 90* 28-30. *Includes Expert Opinion section* by R. M. White

W

Wheeler, Harold A. Comments on 'Spectral Lines—Goodbye, inch' by D. Christiansen; *SPEC Jun 90* (Original item, Mar 90 23)
Whittaker, William L., and Takeo Kanade. Japan robotics for unmanned space exploration; *SPEC Dec 90* 64-67
Wilde, James Stop, in the name of law (Ltr.); *SPEC Jan 90* 6
Wilde, James P. Living with metrication (Ltr.); *SPEC Oct 90* 18
Williams, Sydney B. Comments on 'Electromagnetic fields: The jury's still out—I: Biological effects' by I. Nair and M. G. Morgan; *SPEC Dec 90* 16 (Original article, Aug 90 23-27)
Wolff, Michael Van de Graaff's generator; *SPEC Jul 90* 46
Wood, Roger. Magnetic megabits; *SPEC May* 32-33, 36-38
Woodbury, Eric J. LFR (letter from reader) (Ltr.); *SPEC Sep 90* 11

Y

Youst, David B., and Laurence Lipsett. The technical ladder gets harder to climb; *SPEC Sep 90* 46-47

Z

Zelby, Leon W. Comments on 'The electronic hobbyist' by R. W. Lucky; *SPEC Sep 90* 11 (Original item, Jul 90 6)
Zimmerman, Roger S. Review of 'Silicon Dreams: Information, Man, and Machine' (Lucky, Robert W.; 1989); *SPEC May 90* 12-13
Zorpette, Glenn. Technology '90: Minis and mainframes; *SPEC Jan* 30-34. *Includes Expert Opinion section* by S. E. Nelson

Zorpette, Glenn. Technology '90: Power and energy; *SPEC Jan 90* 44-46. *Includes Expert Opinion section* by H. N. Scherer, Jr.
Comments by Somberg, H., *SPEC Apr. 90* 44-46
Zorpette, Glenn. Applications '90: The media event; *SPEC Feb 90* 23
Zorpette, Glenn. New pay phones hit the street; *SPEC May 90* 28-31
Zorpette, Glenn. Electrotechnology: '92 and beyond: Power and energy; *SPEC Jun 90* 28-30
Comments by Baker, M. H., *SPEC Oct 90* 6
Zorpette, Glenn, *see* Chen, Katherine T., *SPEC Jun 90* 32-33
Zorpette, Glenn. The major players: Multinationals on the move; *SPEC Jun 90* 50-52
Zorpette, Glenn, and Gary Stix. Nuclear waste: The challenge is global; *SPEC Jul 90* 18-23
Zorpette, Glenn, and Gary Stix. Nuclear waste: Learning from nature; *SPEC Jul 90* 23-24, 48
Zorpette, Glenn. Electronics consortia to impact products for generations; *SPEC Oct 90* 50-52, 57-58
Zorpette, Glenn. Defense: Suppliers are challenged to downsize gracefully as they seek to diversify; *SPEC Nov 90* 33-36
Zorpette, Glenn. Fish and hydroelectricity: Engineering a better coexistence; *SPEC Dec 90* 68-70

SUBJECT INDEX

A

Adaptive systems
expert system that tailors its real-time responses to fighter pilot's flying style. *Rouse, William B., + , SPEC Mar 90* 38-41†
Aerospace industry
European Community; aerospace and defense after 1992. *Esch, Karl, SPEC Jun 90* 30-32
Air-traffic control
recent developments in transportation. *Murphy, Erin E., SPEC Jan 90* 47-48†
Air transportation
European Community; transportation after 1992. *Murphy, Erin E., SPEC Jun 90* 26-28
limitations of TCASII onboard aircraft collision-avoidance system. *Gunny, E. R., SPEC Jul 90*
Aircraft; cf. Military aircraft
Aircraft expert systems
expert system that tailors its real-time responses to fighter pilot's flying style. *Rouse, William B., + , SPEC Mar 90* 38-41†
Aircraft reliability
correction to 'Aging aircraft: Too old to fly?' (Jun 89 28-31). *Murphy, Erin E., SPEC Mar 90* 16
Analog integrated circuits
affordable analog design using microcomputer software. *Hines, John R., SPEC Nov 90* 60, 62, 64, 66-67, 93
Analog systems
affordable analog design using microcomputer software. *Hines, John R., SPEC Nov 90* 60, 62, 64, 66-67, 93
Antennas
recent developments in antennas. *Chen, Katherine T., SPEC Feb 90* 46-47
Artificial intelligence
proposed international R&D on intelligent manufacturing system. *Jurgen, Ronald K., SPEC Nov 90* 122-124
Audio recording
recent developments in [illegible]er electronics. *Jurgen, Ronald K., SPEC Feb 90* 39-41†
Awards
1990 IEEE field awards. *SPEC Sep 90* 55-56
1990 recipients of major IEEE awards. *SPEC Aug 90* 60-61
Aviation/Space Writer's Association Award of Excellence to Trudy E. Bell and Karl Esch. *Christiansen, Donald, SPEC Aug 90* 21
Draper Award [illegible] vehicle for emphasizing importance of engineering to public and to scientific community. *Christiansen, Donald, SPEC Feb 90* 21
IEEE service awards and prize papers. *SPEC Dec 90* 76-77

B

Behavioral science; cf. Human factors; Psychology
Biological radiation effects, electromagnetic
overreaction to possible dangers of EM fields in US (Speakout). *Adair, Eleanor R., SPEC Aug 90* 11, 14
possible biological effects of household and powerline EM fields. *Nair, Indira, + , SPEC Aug 90* 23-27†
societal reverberations of setting standards for exposure to power-frequency and household EM fields. *Fitzgerald, Karen, SPEC Aug 90* 27-32
Biological radiation effects, electromagnetic; cf. Power transmission biological effects
Biomagnetics
recent developments in medical electronics. *Fitzgerald, Karen, SPEC Jan 90* 52-54†
Biomechanics
using high-speed video and PCs to analyze motion of athletes. *Perry, Tekla S., SPEC Apr 90* 43-44
Biomedical imaging, MRI
recent developments in medical electronics. *Fitzgerald, Karen, SPEC Jan 90* 52-54†
Biomedical imaging, X-ray
picture archiving and communication systems (PACS) for handling X-ray overload. *Dallas, William J., SPEC Apr 90* 33-36†
Biomedical radiation applications, X-ray; cf. Biomedical imaging, X-ray
Book reviews
America's Struggle for Leadership in Technology (Derain, J.-C.; 1990). *Fields, Craig, SPEC Dec 90* 11-12
Breakout into Space: Mission for a Generation (Elias, G. H.; 1990). *Gabrynowicz, Joanne Irene, SPEC Sep 90* 12-13
Cold Fusion: The Making of a Scientific Controversy (Peat, F. D.; 1990). *Stein, Dale F., SPEC Sep 90* 13-14
Elements of Computer Music (Moore, F. R.; 1990). *Pohlmann, Ken C., SPEC Oct 90* 16, 18
Gallium Arsenide Digital Integrated Circuit Design (Long, S. and Butner, S.; 1990). *Cates, Ron, + , SPEC Nov 90* 11-12
Is Korea The Next Japan? (Kang, T. W.; 1989). *Kim, Wan Hee, SPEC Mar 90* 12-13
Mars Beckons (Wilford, J. N.; 1990). *Levin, Gilbert V., SPEC Dec 90* 11
Megamistakes: Forecasting and the Myth of Rapid Technological Change (Schnaars, S. P.; 1989). *Saffo, Paul, SPEC Feb 90* 17-18
Mind Children: The Future of Robot and Human Intelligence (Moravec, H.; 1988). *Shaw, Robert E., SPEC Jan 90* 12-13
Radar Development to 1945 (Burns, R., *Ed.*; 1989). *Dodington, Sven, SPEC Jun 90* 12-13
Rust to Riches: The Coming of the Second Industrial Revolution (Rutledge, J., and Allen, D.; 1989). *Greenwood, Ronald G., SPEC Jul 90* 12-13
Shared Minds: The New Technologies of Collaboration (Schrage, M.; 1990). *Saffo, Paul, SPEC Nov 90* 11
Silicon Dreams: Information, Man, and Machine (Lucky, Robert W.; 1989). *Zimmerman, Roger S., SPEC May 90* 12-13
The Chip War: The Battle for the World of Tomorrow (Warhofsky, F. C.; 1989). *Heilmeier, George H., SPEC Apr 90* 15-16
The Cuckoo's Egg (Stoll, C.; 1989). *Courtney, Robert H., Jr., SPEC Aug 90* 15-16
The Managerial Mystique: Restoring Leadership in Business (Zaleznik, A.; 1989). *Goldman, Jack E., SPEC Oct 90* 16
Business; cf. International trade
Business communication; cf. Professional communication
Business economics
discussion by US industry executives on problems resulting from reduced defense spending. *Rosenblatt, Alfred, SPEC Nov 90* 37-41
open questions on effects of defense spending cuts (Spectral Lines). *Christiansen, Donald, SPEC Nov 90* 29

C

CAM (computer-aided manufacturing); cf. Manufacturing automation
CASE; cf. Computer-aided software engineering
Cellular land mobile radio; cf. Land mobile radio cellular systems
Chinese/Japanese characters
word processing in Japan. *Mori, Kenichi, + , SPEC Aug 90* 46-48
Circuit analysis
Thévenin's theorem for circuit design and analysis. *Brittain, James E., SPEC Mar 90* 42†
Circuit boards; cf. Printed circuits
Circuit reliability; cf. Integrated-circuit reliability
Communication industry
problems for privatized Japanese telecommunications industry posed by ISDN environment. *Saito, Tadao, SPEC Nov 90* 126-128
recent developments in telecommunications. *Bell, Trudy E., SPEC Feb 90* 31-33†
Communication satellites; cf. Satellite communication
Communication switching; cf. Packet switching
Communication system security
blue box phone frauds; solution by separating signaling information from voice signal. *Flory, David, SPEC Nov 90* 117-119
Communication systems
[illegible] on 'Speakout—Partnership and a professional revival' by D. Lundstrom. *Platts, George F., SPEC Jan 90* 6 (Original item, Oct 89 12)
European Community; telecommunications after 1992. *Stix, Gary, SPEC Jun 90* 25-26
Communication systems; cf. Data communication; Image communication; Optical fiber communication; Satellite communication
Communication terminals
burgeoning array of telephone services and equipment. *Perry, Tekla S., SPEC Jul 90* 25-28†
private pay phone technology and regulation. *Zorpette, Glenn, SPEC May 90* 28-31
Component reliability; cf. Integrated-circuit reliability
Computer-aided design; cf. Design automation
Computer-aided manufacturing; cf. Manufacturing automation
Computer-aided software engineering
status of and demand for CASE tools. *Spectrum staff, SPEC Nov 90* 78-81
Computer applications
book review; Shared Minds: The New Technologies of Collaboration (Schrage, M.; 1990). *Saffo, Paul, SPEC Nov 90* 11

Computer communication; cf. Data communication
Computer graphics
LabView, virtual instrument that provides simple, graphical way to set up and run instruments on PC. *Santori, Michael, SPEC Aug 90* 36-39
Computer graphics software
software for data acquisition, analysis, and display. *Spectrum staff, SPEC Nov 90* 86-89
Computer industry
European Community; microelectronics and computers after 1992. *Chen, Katherine T., + , SPEC Jun 90* 32-33
Computer input/output
speculation on talking computer that filters information (Reflections). *Lucky, Robert W., SPEC Jan 90*
Computer interfaces, human factors
comments on 'Of mice and menus: Designing the user-friendly interface' by T. S. Perry and J. Voelcker. *Longstaff, Fred M., SPEC Jan 90* 6 (Original article, Sep 89 46-51)
comments on 'Of mice and menus: Designing the user-friendly interface' by T. S. Perry and J. Voelcker. *Dorn, Philip H., SPEC Jan 90* 6 (Original article, Sep 89 46-51)
use of task analysis and rapid prototyping to develop more compatible human–computer interfaces. *Nickerson, Raymond S., + , SPEC Jul 90* 40-43†
Computer languages
recent developments in system software. *Murphy, Erin E., + , SPEC Jan 90* 38-40†
Computer network security
comments on 'The quest for intruder-proof security systems' by K. Fitzgerald. *Stallman, Richard, SPEC Feb 90* 6 (Original article, Aug 89 22-26)
Computer networks; cf. Local area networks
Computer operating systems; cf. Software, operating systems
Computer peripherals; cf. Printers
Computer protection
protecting computer systems against power transients. *Martzloff, François, SPEC Apr 90* 37-40†
Computer security
book review; The Cuckoo's Egg (Stoll, C.; 1989). *Courtney, Robert H., Jr., SPEC Aug 90* 15-16
recent developments in system software. *Murphy, Erin E., + , SPEC Jan 90* 38-40†
Computers
history and early development of stored program concept. *Aspray, William, SPEC Sep 90* 51
recent developments in minis and mainframes. *Zorpette, Glenn, SPEC Jan 90* 30-34†
Computers; cf. Microcomputers; Minicomputers; *Specific application*
Consumer products
complexity of consumer products (Spectral Lines). *Christiansen, Donald, SPEC Apr 90* 19
European Community; consumer electronics after 1992. *Perry, Tekla S., SPEC Jun 90* 33-34
Control systems; cf. Digital control; Manufacturing automation
Costs; cf. Economics
Coupling; cf. Electromagnetic coupling

D

Data acquisition; cf. Measurement-system data handling
Data communication
recent developments in data communication. *Stix, Gary, SPEC Jan 90* 35-37†
Data communication; cf. Integrated services digital networks; Integrated voice/data communication; Local area networks; Measurement- system data handling
Data processing; cf. Measurement-system data handling
Data security; cf. Computer security
Design
qualities of elegant design (Spectral Lines). *Christiansen, Donald, SPEC Jun 90* 19
Design automation
reconciling conflicting design-automation standards. *Murphy, Erin E., SPEC Mar 90* 44-45
Design automation; cf. Design automation software
Design automation software
affordable analog design using microcomputer software. *Hines, John R., SPEC Nov 90* 60, 62, 64, 66-67, 93
evolution of EDIF (Electronic Design Interchange Format) toward universal data exchange among CAE tools for IC design. *Eurich, John P., + , SPEC Nov 90* 68-72
proliferating software for PC board design. *Spectrum staff, SPEC Nov 90* 82-85
recent developments in design tools. *Murphy, Erin E., SPEC Feb 90* 34-36†
user-friendly CAE based on common framework of interface and management software. *Spectrum staff, SPEC Nov 90* 90-92
Digital communication; cf. Data communication; Image communication; Integrated voice/data communication
Digital control
microcontroller selection guidelines. *Vaglica, John J., + , SPEC Nov 90* 106-109
Digital integrated circuits; cf. Integrated circuits; Semiconductor memories; Very-large-scale integration
Disk drives
recent developments in peripherals. *Voelcker, John, SPEC Feb 90* 28-30†
Disk recording
recent developments in peripherals. *Voelcker, John, SPEC Feb 90* 28-30†
Displays; cf. Computer graphics

E

Ecology; cf. Environmental factors
Economics
book review; Rust to Riches: The Coming of the Second Industrial Revolution (Rutledge, J., and Allen, D.; 1989). *Greenwood, Ronald G., SPEC Jul 90* 12-13
shifting economy to 'peacetime' basis (Spectral Lines). *Christiansen, Donald, SPEC Feb 90* 21
Economics; cf. Business economics; Medical economics
Education
challenge posed by exponentially growing body of knowledge (Spectral Lines). *Christiansen, Donald, SPEC Aug 90* 21
growing crisis in student aid funding at colleges (Spectral Lines). *Christiansen, Donald, SPEC Dec 90* 31
innovative approaches in precollege math and science education in US. *Chen, Katherine T., SPEC Dec 90* 44-48
Education; cf. Engineering education
Electric variables measurement
Keithley's phantom repeater; high-input-impedance instrument based on driven-shield principle developed during World War II. *Kaplan, Gadi, SPEC Dec 90* 71
Electrochemical devices; cf. Fuel cells
Electromagnetic analysis
microcomputer-based electromagnetic simulation using greatly refined finite-element-analysis algorithms. *Cendes, Zoltan J., SPEC Nov 90* 73-77, 93
Electromagnetic coupling
measurements and laboratory studies of transient electric fields above thunderstorms (Forum). *Hale, Leslie C., SPEC May 90* 11
Electromagnetic interference, radiated; cf. Radio spectrum management
Electromagnetic radiation; cf. Antennas
Electromagnetic radiation effects; cf. Biological radiation effects, electromagnetic; Power transmission biological effects
Electromagnetic spectrum management; cf. Radio spectrum management
Electronics
demise of electronic hobbyist (Reflections). *Lucky, Robert W., SPEC Jul 90* 6†
Electronics industry
collaborative electronics R&D efforts in US, Europe, and Japan. *Zorpette, Glenn, SPEC Oct 90* 50-52, 57-58
comparison of EIA and AEA and how they help electronics industry. *Jurgen, Ronald K., SPEC May 90* 50-51, 54
European Community; microelectronics and computers after 1992. *Chen, Katherine T., + , SPEC Jun 90* 32-33
profile of Canon Inc., Japanese manufacturer of office automation equipment and cameras. *Chrysler, Mack, SPEC Nov 90* 113-116
profile of Siemens AG, West German electronics company. *Guterl, Fred, SPEC Dec 90* 57-60
ELF radiation effects; cf. Biological radiation effects, electromagnetic; Power transmission biological effects
Embedded processors; cf. Digital control
Employment; cf. Engineering profession
Energy resources
energy strategies for dealing with global warming (Speakout). *Lawrence, Charles W., SPEC Apr 90* 8
Engineering
Draper Award vehicle for emphasizing importance of engineering to public and scientific community. *Christiansen, Donald, SPEC Feb 90* 21
Engineering education
dispelling seven common myths about academic careers. *Suran, Jerome J., SPEC Sep 90* 52-54
educating dyslexic engineers (Speakout). *Frey, Walter W., SPEC Dec 90* 6
Engineering profession
comments on 'Speakout—Partnership and a professional revival' by D. Lundstrom. *Platts, George F., SPEC Jan 90* 6 (Original item, Oct 89 12)
disappearance of loyalty to company (Spectral Lines). *Christiansen, Donald, SPEC Aug 90* 21
dispelling seven common myths about academic careers. *Suran, Jerome J., SPEC Sep 90* 52-54
European Community; engineering profession after 1992. *Chen, Katherine T., SPEC Jun 90* 47-49†
five engineers who blew whistle and survived. *Fitzgerald, Karen, SPEC Dec 90* 49-52
increased amount of time devoted to meetings by engineers in RD&E- and marketing-oriented companies (Speakout). *Penzias, Arno, SPEC Jun 90* 11
nine reasons why good engineers sometimes fail (Speakout). *Heisman, Dan, SPEC Oct 90* 11, 14
problems that arise when US engineers work for Japanese companies. *Perry, Tekla S., SPEC Aug 90* 53-55
profile of Amr Mohsen, who led development of 256-kb CMOS DRAM. *Perry, Tekla S., SPEC May 90* 44-45
profile of Edith W. Martin, Boeing's manager of electronics R&D. *Chen, Katherine T., SPEC Sep 90* 44-45
profile of Narain Hingorani power engineer in India. *Perry, Tekla S., SPEC Dec 90* 61-63
profile of Robert S. Cooper, technological organizer–manager. *Adam, John A., SPEC Jul 90* 44-45

profile of White House chief-of-staff John H. Sununu. *Adam, John A., SPEC Mar 90* 24-26†
readers' responses to request for ethical judgment (Spectral Lines). *Christiansen, Donald, SPEC Jul 90* 17
request for ethical judgment on hypothetical situation (Spectral Lines). *Christiansen, Donald, SPEC Apr 90* 19†
worldwide trends in engineering employment for 1990s. *Bell, Trudy E., SPEC Dec 90* 32-43

Engineering
comparison of EIA and AEA and how they help electronics industry. *Jurgen, Ronald K., SPEC May* 50-51, 54

Environmental factors
energy strategies for dealing with global warming (Speakout). *Lawrence, Charles W., SPEC Apr 90* 8
migratory fish problem in hydroelectric plant relicensing and some attempted solutions. *Zorpette, Glenn, SPEC Dec 90* 68-70

Environmental factors; cf. Radioactive pollution

Ethics
secrecy has its price (Spectral Lines). *Christiansen, Donald, SPEC Sep 90* 25

Ethics; cf. Engineering profession

Europe
adverse effects of single European market of 1992 on doing business in Europe (Forum). *Nelson, David A., SPEC Oct* 6, 18
aerospace and defense in single European market environment after 1992. *Esch, Karl, SPEC Jun 90* 30-32
collaborative electronics R&D efforts in US, Europe, and Japan. *Zorpette, Glenn, SPEC Oct 90* 50-52, 57-58
consumer electronics in single European market environment after 1992. *Perry, Tekla S., SPEC Jun 90* 33-34
effects on university research of changes in industrial R&D climate. *Chen, Katherine T., SPEC Oct 90* 73-76
engineering profession in single European market environment after 1992. *Chen, Katherine T., SPEC Jun 90* 47-49†
Europower '92 (special issue). *SPEC Jun 90* 20-60
executives' viewpoints on single European market after 1992. *Perry, Tekla S., SPEC Jun 90* 57-60
microelectronics and computers in single European market environment after 1992. *Chen, Katherine T., + , SPEC Jun* 32-33
multinational corporations in single European market environment after 1992. *Zorpette, Glenn, SPEC Jun 90* 50-52
power and energy in single European market environment after 1992. *Zorpette, Glenn, SPEC Jun 90* 28-30†
preparation for 1992's single European market (Spectral Lines). *Christiansen, Donald, SPEC Jun 90* 19
single European market of 1992; status report. *Kaplan, Gadi, SPEC Jun 90* 22-24
standardization in single European market environment after 1992. *Fitzgerald, Karen, SPEC Jun 90* 44-46
telecommunications single European market environment after 1992. *Stix, Gary, SPEC Jun 90* 25-26
trade with Eastern bloc in single European market environment after 1992. *Murphy, Erin E., SPEC Jun 90* 53-54
tradeoffs in achieving single European market of 1992. *Guterl, Fred, SPEC Jun 90* 36-38,43
transportation in single European market environment after 1992. *Murphy, Erin E., SPEC Jun 90* 26-28
US trade with Europe in single market environment after 1992. *Stix, Gary, SPEC Jun 90* 55-56

Expert systems; cf. Aircraft expert systems

Extraterrestrial exploration
book review; Mars Beckons (Wilford, J. N.; 1990). *Levin, Gilbert V., SPEC Dec 90* 11
Voyager 2's flyby past planet Neptune. *Bell, Trudy E., SPEC Jan 90* 28-29

Extraterrestrial radiation effects; cf. Solar radiation

F

Factory automation; cf. Manufacturing automation

FETs; cf. MESFETs

Finite-element methods
microcomputer-based electromagnetic simulation using greatly refined finite-element-analysis algorithms. *Cendes, Zoltan J., SPEC Nov 90* 73-77, 93

Fuel cells
Japanese effort make fuel cells commercially viable. *Itoh, Noboru, SPEC Sep 90* 40-43

Fuzzy logic
Japanese successes designing with fuzzy logic. *Self, Kevin, SPEC Nov 90* 42-44, 105

G

Gallium materials/devices
book review; Gallium Arsenide Digital Integrated Circuit Design (Long, S. and Butner, S.; 1990). *Cates, Ron, + , SPEC Nov 90* 11-12
high-speed VLSI GaAs circuits for computers and communications. *Cates, Ron, SPEC Apr 90* 25-28

Germany
contrasting high-tech strategies pursued by Germany, Japan, and US. *Chen, Katherine T., SPEC Oct 90* 76-78

Governmental activities/factors
changing role of national laboratories in US. *Adam, John A., SPEC Oct 90* 39-44
comments on 'Speakout—Partnership and professional revival' by D. Lundstrom. *Platts, George F., SPEC Jan 90* (Original item, Oct 89 12)
differences between R&D of government-regulated monopolies and private companies. *Bell, Trudy E., SPEC Oct 90* 46-50
private pay phone technology and regulation. *Zorpette, Glenn, SPEC May 90* 28-31
profile of White House chief-of-staff John H. Sununu. *Adam, John A., SPEC Mar 90* 24-26†
shifting economy to 'peacetime' basis (Spectral Lines). *Christiansen, Donald, SPEC Feb 90* 21
spurring industry to compete in global economy. *Adam, John A., SPEC Apr 90* 20-24

Graphics; cf. Computer graphics

H

Handicapped persons
recent developments in medical electronics. *Fitzgerald, Karen, SPEC Jan 90* 52-54†

HF radar
over-the-horizon radar principles, technology, and applications. *Headrick, James M., SPEC Jul 90* 36-39

High-speed integrated circuits
GaAs VLSI circuits for computers and communications. *Cates, Ron, SPEC Apr 90* 25-28

History
book review; Radar Development to 1945 (Burns, R., *Ed.*; 1989). *Dodington, Sven, SPEC Jun 90* 12-13
comments on 'The bombsight war: Norden vs. Sperry' by L. Searle. *Ruggiero, Angelo, SPEC Feb 90* 6 (Original article, Sep 89 60-64)
development of transcontinental telegraph system. *Finn, Bernard, SPEC Aug 90* 58-59
Keithley's phantom repeater; high-input-impedance instrument based on driven-shield principle developed during World War II. *Kaplan, Gadi, SPEC Dec 90* 71
stored program concept's history and early development. *Aspray, William, SPEC Sep 90* 51
Van de Graaf generator. *Wolff, Michael F., SPEC Jul 90* 46

Human factors
book review; Silicon Dreams: Information, Man, and Machine (Lucky, Robert W.; 1989). *Zimmerman, Roger S., SPEC May 90* 12-13

Human factors; cf. Computer interfaces, human factors; Handicapped persons; Psychology

Hydroelectric power generation
25-Hz hydroelectric generators on Niagara River operating since early 20th century. *Barnett, Robert D., SPEC Nov 90* 120-121
migratory fish problem in hydroelectric plant relicensing and some attempted solutions. *Zorpette, Glenn, SPEC Dec 90* 68-70
recent developments in power and energy. *Zorpette, Glenn, SPEC Jan 90* 44-46†

I

IEEE publications
high rating by IEEE membership for Spectrum, other publications. *Christiansen, Donald, SPEC Aug 90* 21

IEEE Spectrum
conversion to metric in future issues of Spectrum (Spectral Lines). *Christiansen, Donald, SPEC Mar 90* 23†
high rating by IEEE membership for Spectrum, other publications (Spectral Lines). *Christiansen, Donald, SPEC Aug 90* 21
letter on excessive use of acronyms. *Woodbury, Eric J., SPEC Sep 90* 11
readers' ratings of last year's Spectrum articles (Spectral Lines). *Christiansen, Donald, SPEC Mar 90* 23

Image communication
picture archiving and communication systems (PACS) for handling X-ray overload. *Dallas, William J., SPEC Apr 90* 33-36†

Image storage
picture archiving and communication systems (PACS) for handling X-ray overload. *Dallas, William J., SPEC Apr 90* 33-36†

Industrial control; cf. Manufacturing automation

Industrial electronics
recent developments in industrial electronics. *Kaplan, Gadi, SPEC Feb 90* 42-43†

Infrared communication; cf. Optical fiber communication

Innovation; cf. Technological innovation

Instrumentation; cf. Measurement

Integrated-circuit design
book review; Gallium Arsenide Digital Integrated Circuit Design (Long, S. and Butner, S.; 1990). *Cates, Ron, + , SPEC Nov 90* 11-12
recent developments in design tools. *Murphy, Erin E., SPEC Feb 90* 34-36†
Thévenin's theorem for circuit design and analysis. *Brittain, James E., SPEC Mar 90* 42†

Integrated-circuit fabrication; cf. Integrated-circuit packaging

Integrated-circuit interconnections
multichip modules that interconnect multiple bare dice by means of stack of conductive and dielectric thin films. *Johnson, Robert R., SPEC Mar 90* 34-36, 46, 48

READER GUIDE TO PRODUCTS AND SERVICES

INNOVATIVE NEW SERIES

IEEE Educational Activities is publishing two new monograph series for engineers in easy-to-use handbook format.

Engineer's Guide To Business
To commence publication in Spring 1991, the series brings a practical approach to training in nontechnical skills for the engineer who wants to increase his business acumen. Topics to be dealt with include written communications, oral presentations, and budgeting.

Professional Case Studies
First-hand professional experiences of recognized experts offer engineers the opportunity to learn from the mistakes and successes of their colleagues. The first two titles—to be published in Spring 1991—are **Electric Transmission Systems** by John Cassava and **Local Oxidation of Silicon** by Else Kooi.

For more information, CIRCLE #81 on the Reader Service Card.

NEW VIDEO TUTORIALS

EUROPEAN COMMUNITY 1992
Presented by Deborah Flaherty Kizer, AT&T International
Any company concerned with the future of its overseas trade cannot afford to ignore the progress that the European Community has made toward a unified market. The goal of the 12 member states—to achieve a true single market without barriers to the movement of goods, services, capital, and people—is scheduled to come to fruition in 1992. This program explores the ways U.S. businesses can prepare for 1992, and it discusses the factors that provided the impetus for the European program and its progress so far.
Product No. HV0164-4
Recording Date: August 1990
Run Time: 40 min/1 VHS Tape
Standard: NTSC, PAL
List Price: Available only to IEEE members
Member Price: $59.95

For more information, CIRCLE #82 on the Reader Service Card.

VIDEOCONFERENCE

TOTAL QUALITY
The Malcolm Baldrige Award Approach to Quality Management
Presented by Edward Fuchs, AT&T Bell Laboratories; Edward Finein, Xerox Corp.; and William Smith Jr., Motorola Inc.
Over the past two decades, non-U.S. competition producing high-quality products has captured large market shares in many industries once dominated by U.S. corporations. In response to this challenge, Congress in 1987 instituted the Malcolm Baldrige National Quality Award Program.
Since its inception, the Baldrige Award has become the equivalent of the Nobel Prize for quality management in the United States. Today, many companies are using the Baldrige quality criteria to evaluate their own quality-improvement efforts. The application process itself is quickly becoming the benchmark for total quality in the United States.
This videoconference provides a thorough understanding of the National Quality Award Program from the perspective of a Senior Baldrige Examiner. In addition, two in-depth case studies from past Baldrige Award-winning quality programs at Xerox Corp. and Motorola Inc. are presented. Xerox focuses on its benchmark process and Motorola on its "Six Sigma Quality" approach.
(Upon request, the videoconference program is available with transcripts of all formal presentations for non-English speaking countries.)
Product No: EV0394-7 (VC36)
Conference Date: September 13, 1990
Run time: 3 hours/2 VHS Tapes
Standard: NTSC, PAL
Member Price: $650.00
List Price: $1800 University Price: $850

For more information, CIRCLE #83 on the Reader Service Card.

From IEEE PRESS
Books for Professionals

The Making of a Profession: *A Century of Electrical Engineering in America*
Written by A. Michal McMahon. 1984. 320 pages. ISBN—0-87942-173-8.
Contents: Foreword; Preface; At the Dawn of Electrical Engineering; The New Engineering Age; Electrical Engineers and the Age of Organization; The Professional Standing of Electrical Engineering; The Radio Era; The New World of Electronics Engineering; The Growth of Electronics and the Path to Merger; The IEEE and the New Professionalism; Author and Subject Indexes.
Hardcover. Order No. PC01677-PBS
Price: $38.90, Member; $51.80, List.
(Continued overleaf)

READER SERVICE (CIRCLE NUMBERS)

1 PRODUCT INFORMATION (FROM ADVERTISEMENTS)

1		11	16	21	26	31	36	41	46	51	56	61	66	71	76	81	86	91	96
2	7	12	17	22	27	32	37	42	47	52	57	62	67	72	77	82	87	92	97
3	8	13	18	23	28	33	38	43	48	53		63	68	73	78	83		93	98
4	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79	84	89	94	
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

MEMBERSHIP INFO

300 Regular 301 Student

Print or Type only

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Country _____ Business Phone _____

If this represents a change in address, please fill out form on p. 9

3 ADDITIONAL COMMENTS

_____

_____

I would like: _____

DELIVERY: I received this issue _____ (date).

Void after March 1, 1991 *Void overseas April 1, 1991* **12**

READER FEEDBACK (CIRCLE NUMBERS)

2 EDITORIAL MATTER

Article/Item	Content		
	[illegible]	[illegible]	[illegible]
EE engineering disruptions	200	201	202
Precollege math and science	203	204	205
Jtech on robots	206	207	208
Software for utilities	209	210	211
Company profile: Siemens	212	213	214
Profile: Hingorani	215	216	217
Whistle-blower survivors	218	219	220
Phantom repeater	221	222	223
Hydropower relicensing	224	225	226
Automotive electronics	227	228	229
IEEE awards	230	231	232
Newslog	233	234	235
EEs' tools & toys	236	237	238
Faults & failures	239	240	241
Program notes	242	243	244
Engineer at large	245	246	247
Innovations	248	249	250

Did you find this material stimulating or thought-provoking?

Item	Yes	No
Spectral lines	251	252
Forum	253	254
Speakout	255	256
Books	257	258

READER GUIDE TO PRODUCTS AND SERVICES

Turning Points in American Electrical History
A Book of Selected Reprints
Edited by James E. Brittain, Georgia Institute of Technology, 1977. 416 pages.
ISBN—0-87942-081-2.
Contents: Preface; Introduction; Franklin's Electrochemical Battery and Electrical Theory and Lightning Rod; The Electromagnetism; Telegraphy and Telephony; Electric Lighting; Professionalization; Electric Lights and Power Systems; Electrical Communication Systems; Electronics; Feedback Control and Computers. 64 reprinted papers.
Paperbound. Order No. PP00836-PBS
Price: $15.90, Member; $21.20, List.

To order . . . just dial 1-800-678-IEEE. Or CIRCLE #88 on the Reader Service Card.

Nominations sought for IEEE Fellows

Members are invited to submit nominations for members to be elected to the Fellow grade. Candidates must be Senior Members and have been members for at least five years before the one in which the election is to take place. However, the five-year membership requirement may be waived for a candidate in professional practice, and so qualified as a Senior Member, in a geographical area where it was difficult to become a member previously.

The Fellow Committee bases its evaluation on the nominee's qualifications in six categories: individual professional contributions; evaluation by an IEEE Society; tangible and verifiable evidence of technical accomplishments, such as technical publications, patents, or reports; confidential opinions of Fellows who are qualified to judge the candidate's work; service to the IEEE and other professional societies; and total years in the profession.

Only the revised 1991 nomination form will be accepted. It is due by April 30, 1991.

For more information, contact: Staff Secretary, IEEE Fellow Committee, 345 E. 47th St., New York, N.Y. 10017. Or CIRCLE #85 on the Reader Service Card.

CAREERS IN ENGINEERING

IEEE-U.S. Activities has issued a career guidance publication, "Your Career in the Electrical, Electronics, and Computer Engineering Fields," aimed at high school students. It highlights typical tasks performed by electrical engineers, computer scientists, and technologists and technicians, and it lists the high school and college curricula needed to qualify for such positions. It also describes the IEEE and provides sources for information on scholarships.

For complimentary copies, CIRCLE #86 on the Reader Service Form.

National Engineers Week February 17–23, 1991

During National Engineers Week, February 17-23, 1991, thousands of engineers will participate in Discover "E," the only national teach-in of its kind designed to help students discover the excitement of engineering. This year's Discover "E" program focuses on engineering and the environment.

National Engineers Week sponsors ask you to help teach a science or math class at a local school or to initiate some other student program. Through Discover "E," you can motivate today's students to become tomorrow's engineers.

For information on how to participate in National Engineers Week and Discover "E," contact your engineering Society Chapter or headquarters office. Or CIRCLE #84 on the Reader Service Card.

HOW TO JOIN AN IEEE SOCIETY

As a member of the IEEE, you automatically qualify for membership in any of its 35 technical Societies. Society membership will give you ready access to state-of-the-art meetings and conferences in your technical areas of interest and to their published proceedings. You will have the opportunity to meet experts from other organizations and to participate in technical activities with today's leaders in engineering and science, industry, government, and academia. Of course, you may join as many of the IEEE's 35 Societies as meet your needs.

At least one periodical is included with each Society fee, keeping you informed of the latest developments in your field. All Society periodicals and conference records are available to members at greatly reduced prices.

Take this opportunity to broaden your outlook and open your mind to new concepts, new techniques, and new fields of interest.

For more information on Society membership, periodicals, and fees, CIRCLE #87 on the Reader Service Card.

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS MAIL PERMIT NO. 1332, NEW YORK, N.Y.

POSTAGE WILL BE PAID BY ADDRESSEE

IEEE SPECTRUM
Creative Data Center
650 South Clark
Chicago IL 60605-9918

Integrated-circuit packaging
multichip modules that interconnect multiple bare dice by means of stack of conductive and dielectric thin films. *Johnson, Robert R., SPEC Mar 90* 34-36, 46, 48
Integrated-circuit reliability
functional abstraction as alternative to simulation for anticipating timing glitches. *Lathrop, Richard H., + , SPEC Apr 90* 41-42
Integrated circuits
book review; The Chip War: The Battle for the World of Tomorrow (Warhofsky, F. C.; 1989). *Heilmeier, George H., SPEC Apr 90* 15-16
recent developments in solid-state devices. *Santo, Brian, + , SPEC Jan 90* 41-43†
Integrated circuits; cf. Analog integrated circuits; High-speed integrated circuits; Semiconductor memories; Very-large-scale integration
Integrated circuits industry; cf. Electronics industry
Integrated services digital networks
European Community; telecommunications after 1992. *Stix, Gary, SPEC Jun 90* 25-26
problems for privatized Japanese telecommunications industry posed by ISDN environment. *Saito, Tadao, SPEC Nov 90* 126-128
recent developments in telecommunications. *Bell, Trudy E., SPEC Feb 90* 31-33†
Integrated voice/data communication
engineering advances in satellite communications. *Campanella, S. Joseph, SPEC Aug 90* 49-52
Interactive computing, human factors; cf. Computer interfaces, human factors
International trade
European preparation for 1992's single market (Spectral Lines). *Christiansen, Donald, SPEC Jun 90* 19
how manufacturing processes, R&D alliances, and government policies advance competitiveness in borderless economies. *Adam, John A., SPEC Sep 90* 26-31
spurring industry to compete in global economy. *Adam, John A., SPEC Apr 90* 20-24
ISDN; cf. Integrated services digital networks

J

Japan
collaborative electronics R&D efforts in US, Europe, and Japan. *Zorpette, Glenn, SPEC Oct 90* 50-52, 57-58
contrasting high-tech strategies pursued by Germany, Japan, and US. *Chen, Katherine T., SPEC Oct 90* 76-78
designing with fuzzy logic. *Self, Kevin, SPEC Nov 90* 42-44, 105
differences between R&D of government-regulated monopolies and private companies. *Bell, Trudy E., SPEC Oct 90* 46-50
effects on university research of changes in industrial R&D climate. *Chen, Katherine T., SPEC Oct 90* 73-76
highlight of NASA/NSF study on Japanese robotics for space and other extreme environments. *Whittaker, William L., + , SPEC Dec 90* 64-67
making fuel cells commercially viable. *Itoh, Noboru, SPEC Sep 90* 40-43
problems for privatized Japanese telecommunications industry posed by ISDN environment. *Saito, Tadao, SPEC Nov 90* 126-128
word processing in Japan. *Mori, Kenichi, + , SPEC Aug 90* 46-48

L

Land mobile radio cellular systems
recent developments in telecommunications. *Bell, Trudy E., SPEC Feb 90* 31-33†
Languages; cf. Computer languages
Lasers
recent developments in Soviet optoelectronics. *Chen, Katherine T., SPEC Feb 90* 44-45
Legal factors
extension of software copyright protection in Lotus vs. Paperback decision (Legal Aspects). *Miller, Joel, SPEC Nov 90* 18
Lightning
measurements and laboratory studies of transient electric fields above thunderstorms (Forum). *Hale, Leslie C., SPEC May 90* 11
Local area networks
recent developments in data communication. *Stix, Gary, SPEC Jan 90* 35-37†
Logic design; cf. Timing
Logistics; cf. Military procurement

M

Magnetic disk recording; cf. Magnetic recording/reading heads
Magnetic films/devices
advances in high-density magnetic disk storage. *Wood, Roger, SPEC May 90* 32-33, 36-38
Magnetic materials/devices; cf. Biomagnetics
Magnetic recording/reading heads
advances in high-density magnetic disk storage. *Wood, Roger, SPEC May 90* 32-33, 36-38
Magnetic resonance imaging; cf. Biomedical imaging, MRI
Magnetic transducers; cf. Magnetic recording/reading heads
Management
book review; The Managerial Mystique: Restoring Leadership in Business (Zaleznik, A.; 1989). *Goldman, Jack E., SPEC Oct 90* 16
Man–machine systems; cf. Human factors
Manufacturing automation
proposed international R&D on intelligent manufacturing system. *Jurgen, Ronald K., SPEC Nov 90* 122-124
RS/1 tool for computer-integrated manufacturing. *Lee, Richard, SPEC Jul 90* 14
Measurement
LabView, virtual instrument that provides simple, graphical way to set up and run instruments on PC. *Santori, Michael, SPEC Aug 90* 36-39
recent developments in instrumentation. *Fitzgerald, Karen, SPEC Feb 90* 37-38†
Measurement; cf. Electric variables measurement; Oscilloscopes
Measurement-system data handling
software for data acquisition, analysis, and display. *Spectrum staff, SPEC Nov 90* 86-89
Mechanical factors; cf. Biomechanics
Medical economics
contribution of technology to accelerating cost of medical care (Spectral Lines). *Christiansen, Donald, SPEC Jan 90* 25
correction to 'Technology in medicine: Too much too soon?'(Dec 89 24-29). *Fitzgerald, Karen, SPEC Feb 90*
correction to 'Technology in medicine: Too much too soon?'(Dec 89 24-29). *Fitzgerald, Karen, SPEC Mar 90* 16
Meetings; cf. Public speaking
Memories; cf. Image storage; Random-access memories; Semiconductor memories
MESFETs
evaluating nonlinear models for microwave GaAs MESFETs. *Vendelin, George D., SPEC Sep* 48-50
Metropolitan area networks
configurations and protocols of metropolitan area networks. *Morreale, Patricia A., + , SPEC May 90* 40-42
Microcomputer applications
LabView, virtual instrument that provides simple, graphical way to set up and run instruments on PC. *Santori, Michael, SPEC Aug 90* 36-39
using high-speed video and PCs to analyze motion of athletes. *Perry, Tekla S., SPEC Apr 90* 43-44
Microcomputer software
affordable analog design using microcomputer software. *Hines, John R., SPEC Nov 90* 60, 62, 64, 66-67, 93
electromagnetic simulation using greatly refined finite-element-analysis algorithms. *Cendes, Zoltan J., SPEC Nov 90* 73-77, 93
software for data acquisition, analysis, and display. *Spectrum staff, SPEC Nov 90* 86-89
Microcomputers
recent developments in PCs and workstations. *Voelcker, John, SPEC Feb 90* 24-27†
Micromechanical devices
silicon sensors and actuators on chip. *Howe, Roger T., + , SPEC Jul 90* 29-31, 34-35
speculations on micromechanics (Reflections). *Lucky, Robert W., SPEC Mar 90* 6
Microprocessors
microcontroller selection guidelines. *Vaglica, John J., + , SPEC Nov 90* 106-109
Military aircraft
comments on 'The bombsight war: Norden vs. Sperry' by L. Searle. *Ruggiero, Angelo, SPEC Feb 90* 6 (Original article, Sep 89 60-64)
comments on 'The bombsight war: Norden vs. Sperry' by L. Searle. *Baum, Dwight C., SPEC Mar 90* 16 (Original article, Sep 89 60-64)
comments on 'The bombsight war: Norden vs. Sperry' by L. Searle. *Meltzer, Irv, SPEC Mar 90* 16 (Original article, Sep 89 60-64)
comparison of strategic bombers' ability to meet real-world requirements (Speakout). *Daskal, Steven E., SPEC Feb 90*
expert system that tailors its real-time responses to fighter pilot's flying style. *Rouse, William B., + , SPEC Mar 90* 38-41†
Military equipment
European Community; aerospace and defense after 1992. *Esch, Karl, SPEC Jun 90* 30-32
recent developments in aerospace and military technology. *Adam, John A., + , SPEC Jan 90* 49-51†
Military procurement
discussion by US industry executives on problems resulting from reduced defense spending. *Rosenblatt, Alfred, SPEC Nov 90* 37-41
need for defense suppliers in US to downsize gracefully as they seek to diversify. *Zorpette, Glenn, SPEC Nov 90* 33-36
open questions on effects of defense spending cuts (Spectral Lines). *Christiansen, Donald, SPEC Nov 90* 29
trend toward smaller, lethal, more deployable US defense forces. *Adam, John A., SPEC Nov 90* 30-33
Minicomputers
recent developments in minis and mainframes. *Zorpette, Glenn, SPEC Jan 90* 30-34†
Mobile robots
recent developments in robotics. *Chen, Katherine T., SPEC Feb 90* 46-47
Motion analysis
using high-speed video and PCs to analyze motion of athletes. *Perry, Tekla S., SPEC Apr 90* 43-44
MRI; cf. Biomedical imaging, MRI
Multiaccess communication; cf. Time-division multiaccess
Music
book review; Elements of Computer Music (Moore, F. R.; 1990). *Pohlmann, Ken C., SPEC Oct 90* 16, 18

N

NMR; cf. Biomedical imaging, MRI
Nuclear fusion
book review; Cold Fusion: The Making of a Scientific Controversy (Peat, F. D.; 1990). *Stein, Dale F., SPEC Sep 90* 13-14
inconsistent findings on cold fusion. *Zorpette, Glenn, SPEC Feb 90* 23
Nuclear power generation
pictorial of dormant Shoreham nuclear power station. *Fitzgerald, Karen, SPEC May 90* 46-48
quiescent status of Shoreham power plant (Spectral Lines). *Christiansen, Donald, SPEC May 90* 27
recent developments in power and energy. *Zorpette, Glenn, SPEC Jan 90* 44-46†
Nuclear wastes; cf. Radioactive pollution

O

Operating systems; cf. Software, operating systems
Optical fiber communication
communication potential of optical solitons. *Bell, Trudy E., SPEC Aug 90* 56-57
recent developments in Soviet optoelectronics. *Chen, Katherine T., SPEC Feb 90* 44-45
Optical pulses, solitons
communication potential of optical solitons. *Bell, Trudy E., SPEC Aug 90* 56-57
Optical waveguide communication; cf. Optical fiber communication
Oral communication; cf. Public speaking
Oscilloscopes
measuring risetime of high-speed oscilloscopes using 'kickback' from sampling process. *Rush, Ken, + , SPEC Sep 90* 38-39

P

Packaging; cf. Integrated-circuit packaging
Packet switching
engineering advances in satellite communications. *Campanella, S. Joseph, SPEC Aug 90* 49-52
Personal computers; cf. Microcomputers
Photovoltaic power cells
recent developments in power and energy. *Zorpette, Glenn, SPEC Jan 90* 44-46†
Power generation
European Community; power and energy after 1992. *Zorpette, Glenn, SPEC Jun 90* 28-30†
European Community; tradeoffs in achieving single European market of 1992. *Guterl, Fred, SPEC Jun 90* 36-38,43
recent developments in power and energy. *Zorpette, Glenn, SPEC Jan 90* 44-46†
Power generation; cf. Fuel cells; Hydroelectric power generation; Nuclear power generation
Power system protection
preparing for effects of geomagnetic storms on power systems. *Kappenman, John G., + , SPEC Mar 90* 27-33†
Power system transients
protecting computer systems against power transients. *Martzloff, François, SPEC Apr 90* 37-40†
Power systems
integrated multitask software for electric utilities. *Hoffman, Steve, + , SPEC Dec 90* 53-56
Power [illegible]
preparing for effects of geomagnetic storms on power systems. *Kappenman, John G., + , SPEC Mar 90* 27-33†
Power [illegible] biological effects
managing biological risks of power-frequency EM fields. *Morgan, M. Granger, + , SPEC Aug 90* 32-35
possible biological effects of household and powerline EM fields. *Nair, Indira, + , SPEC Aug 90* 23-27†
societal reverberations of setting standards for exposure to power-frequency and household EM fields. *Fitzgerald, Karen, SPEC Aug 90* 27-32
Printed circuits
proliferating software for PC board design. *Spectrum staff, SPEC Nov 90* 82-85
Printers
recent developments in peripherals. *Voelcker, John, SPEC Feb 90* 28-30†
Privacy; cf. Communication system security
Procurement; cf. Military procurement
Professional communication
book review; Shared Minds: The New Technologies of Collaboration (Schrage, M.; 1990). *Saffo, Paul, SPEC Nov 90* 11
difficulty of keeping up with what is going on in office and in technology (Reflections). *Lucky, Robert W., SPEC Nov 90* 6
strategies for information gathering to keep up with technology. *Bell, Trudy E., SPEC Oct 90* 69-73
Professionalism
benefits of checklists (Spectral Lines). *Christiansen, Donald, SPEC Mar 90* 23
Professionalism; cf. Engineering profession
Programming; cf. Software design/development
Protocols
configurations and protocols of metropolitan area networks. *Morreale, Patricia A., + , SPEC May 90* 40-42
Psychology
gaining status from wearing accoutrements of sporting teams or scholastic organizations (Spectral Lines). *Christiansen, Donald, SPEC Dec 90* 31
Public speaking
difficulty of giving short talks (Reflections). *Lucky, Robert W., SPEC Sep 90* 6
reactions to feedback on speeches or writing (Reflections). *Lucky, Robert W., SPEC May 90* 8
Publishing; cf. IEEE publications
Pulse radar; cf. Radar

R

Radar
book review; Radar Development to 1945 (Burns, R., *Ed.*; 1989). *Dodington, Sven, SPEC Jun 90* 12-13
Radar; cf. HF radar
Radiation effects; cf. Radioactive pollution
Radio communication; cf. Satellite communication; Spread-spectrum communication
Radio spectrum management
commercial use of spread spectrum and its benefits. *Schilling, Donald L., + , SPEC Aug 90* 40-41, 44-45
Radioactive pollution
vitrification technique for sealing nuclear wastes and search for geological repositories. *Zorpette, Glenn, + , SPEC Jul 90* 23-24, 48
worlwide problems in disposing of nuclear waste. *Zorpette, Glenn, + , SPEC Jul 90* 18-23
Radiography; cf. Biomedical imaging, X-ray
Rail transportation
European Community; transportation after 1992. *Murphy, Erin E., SPEC Jun 90* 26-28
recent developments in transportation. *Murphy, Erin E., SPEC Jan 90* 47-48†
RAM; cf. Random-access memories
Random-access memories
technology and characteristics of advanced DRAM chips. *Masuoka, Fujio, SPEC Nov 90* 110-112
RD&E
book review; America's Struggle for Leadership in Technology' (Derain, J.-C.; 1990). *Fields, Craig, SPEC Dec 90* 11-12
changes in software development techniques. *Murphy, Erin E., SPEC Oct 90* 44-46
comments on current R&D climate (Spectral Lines). *Christiansen, Donald, SPEC Oct 90* 25
contrasting high-tech strategies pursued by Germany, Japan, and US. *Chen, Katherine T., SPEC Oct 90* 76-78
effects on university research of changes in industrial R&D climate. *Chen, Katherine T., SPEC Oct 90* 73-76
European Community; tradeoffs in achieving single European market of 1992. *Guterl, Fred, SPEC Jun 90* 36-38,43
expansion of R&D in increasingly global environment. *Kaplan, Gadi, + , SPEC Oct 90* 28-33
need for defense suppliers in US to downsize gracefully as they seek to diversify. *Zorpette, Glenn, SPEC Nov 90* 33-36
proposed international R&D on intelligent manufacturing system. *Jurgen, Ronald K., SPEC Nov 90* 122-124
R&D (special issue). *SPEC Oct 90* 26-84
shifting world balance of R&D power; comments by seven leaders from government, industry, and academia. *Perry, Tekla S., + , SPEC Oct 90* 79-82
spurring industry to compete in global economy. *Adam, John A., SPEC Apr 90* 20-24
strategies for information gathering to keep up with technology. *Bell, Trudy E., SPEC Oct 90* 69-73
RD&E economics
changing role of national laboratories in US. *Adam, John A., SPEC Oct 90* 39-44
corporate use of independent contract research organizations. *Fitzgerald, Karen, SPEC Oct 90* 58-60
responding to needs of business division; measuring the payoff. *Jurgen, Ronald K., SPEC Oct 90* 34-39
RD&E management
climbing the corporate technical ladder. *Youst, David B., + , SPEC Sep 90* 46-47
collaborative electronics R&D efforts in US, Europe, and Japan. *Zorpette, Glenn, SPEC Oct 90* 50-52, 57-58
corporate approaches to cutting development time. *Perry, Tekla S., SPEC Oct 90* 61-67
corporate use of independent contract research organizations. *Fitzgerald, Karen, SPEC Oct 90* 58-60
differences between R&D of government-regulated monopolies and private companies. *Bell, Trudy E., SPEC Oct 90* 46-50
responding to needs of business division; measuring the payoff. *Jurgen, Ronald K., SPEC Oct 90* 34-39
strategies for fostering creativity in research laboratories. *Fitzgerald, Karen, SPEC Oct 90* 67-69
RD&E management; cf. Engineering profession
Recording; cf. Audio recording; Disk recording; Video recording
Reliability; cf. Aircraft reliability; Integrated-circuit reliability; Space-vehicle reliability
Risk analysis
managing biological risks of power-frequency EM fields. *Morgan, M. Granger, + , SPEC Aug 90* 32-35

Road-vehicle electronics
putting electronics to work in 1991 car models. *Jurgen, Ronald K., SPEC Dec 90* 72-75
Road vehicles
how manufacturing processes, R&D alliances, and government policies advance competitiveness in borderless economies. *Adam, John A., SPEC Sep 90* 26-31
Robots
book review; Mind Children: The Future of Robot and Human Intelligence (Moravec, H.; 1988). *Shaw, Robert E., SPEC Jan 90* 12-13
highlight of NASA/NSF study on Japanese robotics for space and other extreme environments. *Whittaker, William L., + , SPEC Dec 90* 64-67

S

Satellite communication
engineering advances in satellite communications. *Campanella, S. Joseph, SPEC Aug 90* 49-52
recent developments in telecommunications. *Bell, Trudy E., SPEC Feb 90* 31-33†
Security; cf. Communication system security; Computer security
Semiconductor devices; cf. Electronics industry; Integrated circuits
Semiconductor memories
recent developments in solid-state devices. *Santo, Brian, + , SPEC Jan 90* 41-43†
Semiconductor memories; cf. RAM
Signal processing
emergence of needed DSP software. *Mather, Bruce C., SPEC Nov 90* 52, 54, 57-59, 93
Simulation software
microcomputer-based electromagnetic simulation using greatly refined finite-element-analysis algorithms. *Cendes, Zoltan J., SPEC Nov 90* 73-77, 93
Social factors; cf. Medical economics; Technology social factors
Software
emergence of needed DSP software. *Mather, Bruce C., SPEC Nov 90* 52, 54, 57-59, 93
integrated multitask software for electric utilities. *Hoffman, Steve, + , SPEC Dec 90* 53-56
software for data acquisition, analysis, and display. *Spectrum staff, SPEC Nov 90* 86-89
Software; cf. Computer graphics software; Computer languages; Design automation software; Microcomputer software
Software, operating systems
recent developments in system software. *Murphy, Erin E., + , SPEC Jan 90* 38-40†
Software design/development
changes in software development techniques. *Murphy, Erin E., SPEC Oct 90* 44-46
use of task analysis and rapid prototyping to develop more compatible human–computer interfaces. *Nickerson, Raymond S., + , SPEC Jul 90* 40-43†
Software design/development; cf. Computer-aided software engineering
Software reviews
Matlab interactive numeric computation environment for scientists and engineers. *Santalesa, Richard L., SPEC Jan 90* 16
RS/1 tool for computer-integrated manufacturing. *Lee, Richard, SPEC Jul 90* 14
Solar radiation
preparing for effects of geomagnetic storms on power systems. *Kappenman, John G., + , SPEC Mar 90* 27-33†
Solitons; cf. Optical pulses, solitons
South Korea
book review; Is Korea The Next Japan? (Kang, T. W.; 1989). *Kim, Wan Hee, SPEC Mar 90* 12-13
Space technology
book review; Breakout into Space: Mission for a Generation (Elias, G. H.; 1990). *Gabrynowicz, Joanne Irene, SPEC Sep 90* 12-13
highlight of NASA/NSF study on Japanese robotics for space and other extreme environments. *Whittaker, William L., + , SPEC Dec 90* 64-67
NASA's problems with 'soft' technologies (Spectral Lines). *Christiansen, Donald, SPEC Jul 90* 17
recent developments in aerospace and military technology. *Adam, John A., + , SPEC Jan 90* 49-51†
Voyager 2's flyby past planet Neptune. *Bell, Trudy E., SPEC Jan 90* 28-29
Space-vehicle reliability
correction to 'The space shuttle: A case of subjective engineering' (Jun 89 42-46). *Bell, Trudy E., + , SPEC Mar 90* 16
Speaking; cf. Public speaking
Special issues/sections
Applications '90. *SPEC Feb 90* 22-52
Europpower '92. *SPEC Jun 90* 20-60
R&D. *SPEC Oct 90* 26-84
Technology '90. *SPEC Jan 90* 26-56
Spectrum management; cf. Radio spectrum management
Speech communication; cf. Integrated services digital networks; Integrated voice/data communication
Speechmaking; cf. Public speaking
Spread-spectrum communication
commercial use of spread spectrum and its benefits. *Schilling, Donald L., + , SPEC Aug 90* 40-41, 44-45
Standards
European Community; standardization after 1992. *Fitzgerald, Karen, SPEC Jun 90* 44-46
evolution of EDIF (Electronic Design Interchange Format) toward universal data exchange among CAE tools for IC design. *Eurich, John P., + , SPEC Nov 90* 68-72
recent developments in instrumentation. *Fitzgerald, Karen, SPEC Feb 90* 37-38†
reconciling conflicting design-automation standards. *Murphy, Erin E., SPEC Mar 90* 44-45
societal reverberations of setting standards for exposure to power-frequency and household EM fields. *Fitzgerald, Karen, SPEC Aug 90* 27-32
technical challenges to decentralized system. *Bell, Trudy E., SPEC Sep 90* 32-37
Store-and-forward switching; cf. Packet switching
Subscriber networks; cf. Integrated services digital networks
Subscriber sets; cf. Communication terminals
Superconducting materials/devices
how manufacturing processes, R&D alliances, and government policies advance competitiveness in borderless economies. *Adam, John A., SPEC Sep 90* 26-31
Surges; cf. Power system transients

T

Technical communication; cf. Professional communication
Technological innovation
strategies for fostering creativity in research laboratories. *Fitzgerald, Karen, SPEC Oct 90* 67-69
Technology
Applications '90 (special issue). *SPEC Feb 90* 22-52
book review; Is Korea The Next Japan? (Kang, T. W.; 1989). *Kim, Wan Hee, SPEC Mar 90* 12-13
interviews with executives and scholars on major technology issues for 1990s. *Stix, Gary, SPEC Feb* 48
Technology '90 (special issue). *SPEC Jan 90* 26-56
Technology forecasting
book review; Megamistakes: Forecasting and the Myth of Rapid Technological Change (Schnaars, S. P.; 1989). *Saffo, Paul, SPEC Feb 90* 17-18
Technology social factors
book review; Breakout into Space: Mission for a Generation (Elias, G. H.; 1990). *Gabrynowicz, Joanne Irene, SPEC Sep 90* 12-13
book review; Mind Children: The Future of Robot and Human Intelligence (Moravec, H.; 1988). *Shaw, Robert E., SPEC Jan 90* 12-13
book review; Silicon Dreams: Information, Man, and Machine (Lucky, Robert W.; 1989). *Zimmerman, Roger S., SPEC May 90* 12-13
book review; The Chip War: The Battle for the World of Tomorrow (Warhofsky, F. C.; 1989). *Heilmeier, George H., SPEC Apr 90* 15-16
contribution of technology to accelerating cost of medical care (Spectral Lines). *Christiansen, Donald, SPEC Jan 90* 25
demise of electronic hobbyist (Reflections). *Lucky, Robert W., SPEC Jul 90* 6†
secrecy has its price (Spectral Lines). *Christiansen, Donald, SPEC Sep 90* 25
societal reverberations of setting standards for exposure to power-frequency and household EM fields. *Fitzgerald, Karen, SPEC Aug 90* 27-32
speculation talking computer that filters information (Reflections). *Lucky, Robert W., SPEC Jan 90*
Technology social factors; cf. Risk analysis
Telemetry; cf. Measurement-system data handling
Telephone systems
burgeoning array of telephone services and equipment. *Perry, Tekla S., SPEC Jul 90* 25-28†
technical challenges to decentralized system. *Bell, Trudy E., SPEC Sep 90* 32-37
Text processing
word processing in Japan. *Mori, Kenichi, + , SPEC Aug 90* 46-48
Thermal power generation; cf. Nuclear power generation
Time-division multiaccess
engineering advances in satellite communications. *Campanella, S. Joseph, SPEC Aug 90* 49-52
Timing
functional abstraction alternative to simulation for anticipating timing glitches. *Lathrop, Richard H., + , SPEC Apr 90* 41-42
Trade; cf. International trade
Traffic control; cf. Air-traffic control
Transient analysis; cf. Power system transients
Transportation; cf. Air transportation
TV
European Community; consumer electronics after 1992. *Perry, Tekla S., SPEC Jun 90* 33-34
realities of HDTV broadcasting; letter responding to two earlier letters. *Goeller, Lee, SPEC Sep 90* 11
recent developments in consumer electronics. *Jurgen, Ronald K., SPEC Feb 90* 39-41†
TV receivers
how manufacturing processes, R&D alliances, and government policies advance competitiveness in borderless economies. *Adam, John A., SPEC Sep 90* 26-31

U

United Kingdom
differences between R&D of government-regulated monopolies and private companies. *Bell, Trudy E., SPEC Oct 90* 46-50
United States
book review; America's Struggle for Leadership in Technology' (Derain, J.-C.; 1990). *Fields, Craig, SPEC Dec 90* 11-12

book review; Rust to Riches: The Coming of the Second Industrial Revolution (Rutledge, J., and Allen, D.; 1989). *Greenwood, Ronald G., SPEC Jul 90* 12-13
collaborative electronics R&D efforts in US, Europe, and Japan. *Zorpette, Glenn, SPEC Oct 90* 50-52, 57-58
contrasting high-tech strategies pursued by Germany, Japan, and US. *Chen, Katherine T., SPEC Oct 90* 76-78
effects ■ university research of changes in industrial R&D climate. *Chen, Katherine T., SPEC Oct 90* 73-76
European Community; US trade with Europe in single market environment after 1992. *Stix, Gary, SPEC Jun 90* 55-56
innovative approaches ■ precollege math and science education in US. *Chen, Katherine T., SPEC Dec 90* 44-48
United States; cf. Governmental activities/factors
USSR
recent developments in Soviet optoelectronics. *Chen, Katherine T., SPEC Feb* ■ 44-45

V

Van de Graaff generators
history of Van de Graaff generator. *Wolff, Michael F., SPEC Jul 90* 46
Very-large-scale integration
high-speed VLSI GaAs circuits for computers and communications. *Cates, Ron, SPEC Apr 90* 25-28
Video recording
recent developments in consumer electronics. *Jurgen, Ronald K., SPEC Feb 90* 39-41†
VLSI; cf. Very-large-scale integration

W

Waste materials; cf. Radioactive pollution
Wire communication
development of transcontinental telegraph system. *Finn, Bernard, SPEC Aug 90* 58-59
Wire communication; cf. Optical fiber communication
Wiring; cf. Integrated-circuit interconnections
Word processing; cf. Text processing
Workstations
recent developments in PCs and workstations. *Voelcker, John, SPEC Feb 90* 24-27†
Writing
reactions to feedback on speeches ■ writing (Reflections). *Lucky, Robert W., SPEC May 90* 8

X

X-ray imaging; cf. Biomedical imaging, X-ray

Y

Yield optimization
functional abstraction ■ alternative to simulation for anticipating timing glitches. *Lathrop, Richard H., + , SPEC Apr 90* 41-42

+ Check author entry for coauthors

† Check author entry for subsequent corrections/comments

News Index

Awards (including Citations, Fellowships, Medals, Scholarships, and Prizes)
W.R.G. Baker Prize award to Allen C. Newell....Dec 76
Alexander Graham Bell Medal to Paul Baran....Aug 61
Cledo Brunetti Award to Else Kooi....Sep 55
Control Systems Science and Engineering Award to Karl J. Astrom....Sep 55
Corporate Innovation Recognition to IBM Corp....Dec 76
Harry Diamond Memorial Award to Robert E. Hebner Jr. ....Sep 55
Edison Medal to Archie W. Straiton....Aug 60
Education Medal to James D. Meindl....Aug 61
Richard M. Emberson service award to Harold Chestnut ....Dec 76
Engineering Leadership Recognition to Irwin Dorros and Edson Fregni....Dec 76
Donald G. Fink Prize award to G. David Forney Jr....Dec 76
Founders Medal to Erich Bloch....Aug 60
Herman Halperin Electric Transmission and Distribution Award to John A. Casazza....Sep 55
Richard W. Hamming Medal to Dennis M. Ritchie and Kenneth L. Thompson....Aug 61
Heinrich Hertz Medal to John D. Kraus....Aug 61
Masaru Ibuka Consumer Electronics Award to Norman L. Stauffer....Sep 55
International Communication Award to S. Joseph Campanella....Sep 55
Richard Harold Kaufmann Award to Rene Castenschiold ....Sep 55
Koji Kobayashi Computers and Communications Award to Elwyn R. Kerlekamp....Sep 55
Lamme Medal to Thomas W. Dakin....Aug 60
Medal for Engineering Excellence to John A. Pierce....Aug 61
Morris E. Leeds Award to Ryszard A. Malewski....Sep 55
Morris N. Liebmann Memorial Award to Satoshi Hiyamizu and Takashi Mimura....Sep 55
Medal of Honor to Robert G. Gallager....Aug 60
Jack A. Morton Award to Gregory E. Stillman and Charles M. Wolfe....Sep 55
Frederik Philips Award to Rajinder P. Khosla....Sep 55
Emanuel R. Piore Award to Allen Newell....Sep 55
Haraden Pratt service award to Robert M. Saunders....Dec 76
Judith A. Resnik Award to Douglas K. Waineo....Sep 55
David Sarnoff Award to Leroy L. Chang....Sep 55
Solid-State Circuits Award to Toshiaki Masuhara....Sep 55
Charles Proteus Steinmetz Award to Warren H. Cook....Sep 55
Nikola Tesla Award to Gordon R. Slemon....Sep 55
Browder J. Thompson Memorial Prize to Robert G. Rojas ....Dec 76

B

Brown on environment at IEEE-USA meeting ...May 66

C

CAD poised for change....Sep 78
Calendar....Jan 9; Feb 11; Mar 14; Apr 14; May 14; Jun 14; Jul 11; Aug 8; Sep 8; Oct 8; Nov 8; Dec ■
Coming in *Spectrum*....Jan 80; Feb 72; Mar 62; Apr 60; May 66; Jun 80; Jul 64; Aug 84; Sep 78; Oct 108; Nov 146; Dec 106

D

DRAM consortium just ■ memory....Mar 62

E

EEs' Tools & Toys....Jan 58; Feb 55; Mar 18; Apr 17; May 55; Jun 68; Jul 52; Aug 71; Sep 64; Oct 94; Nov 131; Dec 79
East Germany to be top market....Jun 80
East Europeans join the IEEE....May 66
Emerson spins off defense units....Dec 106
Engineer at large, The....Jan 23; Apr 12; Jul 47; Oct 19; Dec 26
Engineering in the USSR....May 66
Engineers' hard life in Argentina....Aug 84
Engineers in defense to decrease....Feb 72
Engineers needed in Government service....Jan 80
Europe's advanced synchrotron....Dec 106

F

Faults & Failures...Feb 54; Apr 8; Jun 16; Aug 66; Oct 86; Dec 78

H

Hubble Space Telescope probed....Sep 78

I

IEEE Award recipients announced....May 66
IEEE biennial careers conference....Jan 80
IEEE Board approves dues increase....Oct 108
IEEE Board considers an AIEEE....Oct 108
IEEE Board finalizes budget....Jan 80
IEEE Board funds publishing study....Apr 60
IEEE Board meets in Brussels....Jul 64
IEEE Board ponders dues increase....Jul 64
IEEE Board presents Field Awards....Mar 62; Apr 60
IEEE Board selects candidates....Jan 80
IEEE Board selects Fellows....Feb 72
IEEE direct-mail membership campaign....Apr 60
IEEE Fellow nominations sought....Nov 146
IEEE Fellows appointed to PCAST....Apr 60
IEEE insurance plan changes....Nov 146
IEEE internal computer system overhaul....Feb 72
IEEE members surveyed worldwide....Jul 64
IEEE President-Elect candidates....Sep 78
IEEE President-Elect candidates on issues...Jul 64; Oct 108
IEEE President-Elect for 1991 is Merrill W. Buckley Jr. ....Dec 106
IEEE Sections Congress sets priorities....Dec 106
IEEE software prices undercut....Jan 80
IEEE Spectrum education contest winners....May 66
Innovations....Jan 19; Apr 11; Jul 50; Oct 23; Dec 24

J

Japan braces for the big quake....Dec 106
Japan's speedy supercomputers....Nov 146

L

Lotus wins copyright suit....Sep 90

■

Man on the moon is top engineering feat....Feb 72
Managing technology....Mar 9; Jun 15; Sep 22; Nov 26

N

Newslog....Jan 3; Feb 3; Mar 3; Apr 3; May 2; Jun 3; Jul 3; Aug 3; Sep 3; Oct 3; Nov 3; Dec 3
Noyce, co-inventor of IC, dies....Aug 84
Nuclear power for Eastern Europe....Aug 84

P

PCs: smaller not always better....Aug 84
'Peace dividend' means job losses....Nov 146
Program notesFeb 16; Apr 13; Jun 66; Aug 62; Oct 92; Dec 29

S

Southcon procedures criticized....Feb 72
Software bug slows AT&T....Mar 62
Spinoffs....Mar 8; Jun 64; Sep 61; Nov 22

T

Technically speaking...Jan 18; Mar 8; May 20; Jul 51; Sep 16; Nov 24

U

United States can be competitive....Mar 62
United States, EC may work together....Jun 80

V

Video....Feb 14

W

Whatever happened to...?
The sodium-sulfur battery....Feb 19
V/STOL aircraft....May 24
The Sealab program....Aug 68
Project Mohole....Sep 58

Editorial Offices: New York City 212-705-7555 San Francisco 415-282-3608 Washington, D.C. 202-544-3790

EDITORIAL CORRESPONDENCE. IEEE Spectrum, 345 East 47th St., New York, N.Y. 10017, Attn: Editorial Dept. Responsibility for the substance of articles published rests upon the authors, not the IEEE or its members. Letters to the editor may be excerpted for publication.
REPRINT PERMISSION. Libraries: Articles may be photocopied for private use of patrons. A per-copy fee (indicated after the code appearing at the bottom of the first page of each article) must be paid to the Copyright Clearance Center, 29 Congress St., Salem, Mass. 01970. *Instructors:* Isolated articles may be photocopied for noncommercial classroom use without fee. *Other copying or republication:* Contact: Editor, *IEEE Spectrum*.
ADVERTISING CORRESPONDENCE. IEEE Spectrum, 345 East 47th St., New York, N.Y. 10017, Attn: Advertising Dept. 212-705-7760. Also ■ Advertising Sales Offices listing on last page. The publisher reserves the right to reject any advertising.
COPYRIGHTS AND TRADEMARKS. IEEE Spectrum is ■ registered trademark owned by The Institute of Electrical and Electronics Engineers, Inc. EEs' Tools & toys, Faults & failures, Innovations, Managing technology, Newslog, Program notes, Reflections, Speakout, Spectral lines, Spinoffs, Technically speaking, The engineer at large, and Whatever happened to? are trademarks of the IEEE.
GENERAL INQUIRIES: 1-800-678-IEEE; Headquarters: 345 East 47th St., New York, N.Y. 10017, 212-705-7900. *Tel. extensions at headquarters:* General Manager, 7910; Public Relations, 7369; Publishing Services, 7560; Technical Services, 7856. *At other locations:* Regional Activities, Section Services, Educational Activities, 908-981-0060 or write to IEEE Service Center, Box 1331, Piscataway, N.J. 08855; Membership Services, 908-981-0060; Professional Services, 202-785-0017.

PROFESSIONAL CONSULTING SERVICES

ADVERTISING RATES

1 Insertion—$310 12 Insertions—$3360

50% discount to IEEE members on three or more insertions.
If you are an IEEE member, please enclose your membership number with the order.
Copy cannot exceed 1-inch in depth.
No product may be offered for sale.
Advertising restricted to professional engineering and consulting services.
No orders can be accepted by telephone; order and copy must be sent together.
For any further information and closing dates please contact:
Advertising Production Dept., 212-705-7579.

CSE

Communications Systems Engineering, Inc.

- Specializing in Spread Spectrum systems.
- Coherent receivers, DSP implementations.
- Phaselock synthesizers, exciters thru UHF.
- Laboratory and prototyping facilities, CAD.

1004 Amherst Avenue
L.A., CA 90049

Phone or FAX:
(213) 820-6761

THE CONSULTING GROUP

- RF, Microwave & Fiber Optic Systems
- RF, Microwave Filters, Amplifier, Oscillator & Synthesizer/PLL Design.
- Asynchronous, Synchronous Data Transmission, MODEM's Concentrators, Nodes, WAN (X25, SNA) PBX, PAD

71-25 Austin St., Forest Hills, NY 11375 (718) 793-0777

O.C.R. inc

OPTICS • COATING • RESEARCH
• OPTO-MECHANICAL ENGINEERING
• INFRARED SYSTEM ANALYSIS
• FLIR DESIGN & TEST
• HEAD UP DISPLAYS
• SPECTROSCOPIC INSTRUMENTS
• OPTICAL DESIGN & TEST

Marvin Hutt (201) 337-3155
107 MANITO AVE, OAKLAND, N.J. 07436

Analog/Microprocessor Circuits/Instruments
Application Software Assembly to 4GL

PRODUCT DESIGNS

Systems—Hardware & Software

Frank Bosso, P.E.
5 Frandon Drive
Danbury, CT 06811

Bus. (203) 792-8894
Home (203) 744-3437

RF/Analog Circuit Design

- Communications Equipment Design
- Synthesizers/Phase Locked Loops
- Active/Passive/RF Filters
- Analog Signal Processing
- Audio Processing Circuits

RLM Research
P.O. Box 3630
Boulder, CO 80307

Steven L. Maddy
President
Tel: 303/499-7566 FAX: 303/499-0877

NOISE, TRANSIENTS AND INTERFERENCE

- FCC, VDE, EMC/EMI
- Susceptibility, ESD, RF, Transients, Lightning
- Testing & Retrofit for Product Enhancement
- UL, VDE, CSA, Other Safety-Related Specs
- Noise-Immune Designs and Prototypes
- FCC Compliance Training & Retrofits

TKC THE KEENAN CORPORATION
(813) 544-2594

R. Kenneth Keenan
Ph.D., VP Engr.
8609 [redacted] St. North
Pinellas Park, FL 34666

Robert J. Abend, P.E.

Electronics Consultant

Hardware & Software Design—Neural Nets
Optical Pattern Recognition—ATE Design

1265 Palmdale Circle
Palm Bay, FL 32905

Telephone & FAX
(407) 952-2216

RAINES ELECTROMAGNETICS

Consulting Since 1972

- Antennas and Arrays
- Scattering and Radar Cross Sections
- Radhaz & Environmental Impact
- Simulations of Fields & Phenomena

Jeremy K. Raines, Ph.D., P.E.
President (301) 279-2972

Infolytica Corp. (514) 849-8752

*Expert electromagnetics design & analysis using **MagNet 2D** and **3D** FEA software.*

- *motors*
- *transformers*
- *actuators*
- *levitators*
- *CRT design*
- *magnetizing fixtures*
- *recording heads*
- *NMR applications*
- *magnetic bearings*
- *etc. . .*

1140 deMaisonneuve, Suite 1160 Montreal, Canada, H3A 1M8

MicroCircuit Designs, Inc.

Specialized IC Development

INSTRUCTION PROCESSORS
ARITHMETIC PROCESSORS
CACHE, MSU CONTROLLERS
HIGH VOLTAGE ANALOG/DIGITAL
CMOS AND BIPOLAR TECHNOLOGY

2951 Advance Ln, P.O. Box 566, Colmar, PA 18915
215-997-2994 FAX 215-822-6697

CONTROL SYSTEM CONSULTING

- Servo design, high performance motion control, synthesis, system performance, simulation, specs, integration, testing
- Electrical, mechanical, hydraulic
- Defense, aerospace, industrial experience

30 East Gate Road
Danbury, Conn. 06811

A.R. Hazelton
(203) 743-7002

INDUSTRIAL CONTROLS

Custom Microprocessor Based Controls

- Machine Tool Controls
- Punch Press Controls
- Process Controls
- Prototype Production
- Motorola 68xx, 68xxx Systems

Wintriss Engineering
254 Sunset Drive
Encinitas, CA 92024

Vic Wintriss, MSEE
30 Years Experience
Phone (619) 436-8889

Hardware and Software Development Services

- Specialize in developing microprocessor/FPGA based product/systems & embedded software development.
- Analog, video, RF, & digital circuit design facilities.
- Can help with part of or handle the entire project.
- Full microprocessor development systems, I²ICE, CAD/CAM, & PCB layout system.
- Development for Multibus, VME, PC, MCA, LAN & STD.

Applied Computer Techniques, Inc., Orlando, FL
(407) 851-2525 **Incorporated 1978**

RESEARCH AND DEVELOPMENT ELECTRONICS

- Specializing in medical product development
- Ultrasonic Doppler and imaging
- Low noise wideband amplifiers
- Analog and digital signal processing
- Laboratory and prototyping facilities

For further information contact:
Steve M. Gehlbach, Ph.D., President

Kesa Corporation **4701 Patrick Henry Drive #1801**
(408) 748-1814 **Santa Clara, CA 95054**

Charles E. Mullett, P.E. Karl B. Keller

MULLETT ASSOCIATES, INC.

THE POWER SUPPLY DESIGN EXPERTS

Specializing in switching power supply design and prototypes ▪ Design reviews ▪ Product testing and evaluation ▪ Magnetics design ▪ Mag amp regulators, etc.

Let us help you!

5301 Beethoven St., Los Angeles, CA 90066
(213) 306-4075

GOSIP MAP DECnet

- Broadband & Fiber Optic LANs
- Systems Design & Integration
- Courses & Technology Reports

SHIP STAR Associates
Bob Crowder, President
36 Woodhill Dr., Newark, DE 19711
Tel:302-738-7782, FAX:302-738-0855

FIELDBUS NMgt. MMS

IRA J. PITEL, Ph.D.

Consulting, Research and Development in Power Electronics and Magnetics

Power Supplies, Inverters, Converters, Motor Drives, Lighting Controls, Industrial Controls, Transformers, and Special Magnetics.

MAGNA-POWER ELECTRONICS, INC.
135 Route 10 Whippany, NJ 07981
(201) 428-1197

LEONARD R. KAHN, P.E.

Consultant in Communications and Electronics
Single Sideband and Frequency Shift Systems
Diversify Reception - Stereophonic Systems
Modulation Systems
Registered Patent Agent

222 Westbury Ave.
Carle Place, NY 11514
516-222-2221

International Compliance Corporation

Design, Test, & Consulting

- FCC Certification/Verification
- VDE, CISPR, VCCI (Japan)
- "1992" European Compliance Testing
- Product Safety: UL, CSA, IEC, VDE
- Electrostatic Discharge (ESD)
- MIL-STD 461/462, NARTE-Certified Engineer

812 Office Park Circle (214) 221-7071
Lewisville, Texas 75057 TELEX: 403482 (ICC DAL)

MICRO RESEARCH Co., Ltd

We are the top professional of
- **Microcomputer Based Product development**
- **Hardware/Software development**
- **Semi-custom IC development** *-MCU, ASIC, ROM, Voice /Sound/ Melody IC*
- **End Product development**

Please Contact:
4111-15 H.K. Plaza
369 Des Voeux Rd,
West, Hong Kong
Fax:
(852) 858-2693
Tel:
(852) 559-3031
Telex:
74773 MICOR HX

Research, Design, and Development
Leslie M. Orloff, Ph.D.
Consulting in Electronics

ASIC Development—Full Custom, Standard Cell, PLA, Gate Array—Digital/Analog/Microprocessor based.

Solid State Electronic Design and Development meeting environmental, EOS/ESD, EMI, and RFI requirements.

Digital Signal Procssing—Mathematical Analysis, "C", PASCAL, BASIC, & Assembly Lang. Programming.

6 Roughriders Ct., Huntington, NY 11743
(516) 692-6329

Richard W. Brounley, P.E.
RF ENGINEERING CONSULTANT
Specializing in the design of solid state RF transmitters and associated circuits
★ **Complete RF laboratory facilities** ★ **Prototype development** ★ **Pilot production runs** ★ **Production follow-up**
10341 Nicaron Court, Largo, FL 34648
813-393-8177

IOCC
INTEGRATED OPTICAL CIRCUIT CONSULTANTS
Consulting, Contract R&D, and Prototyping
Integrated, Fiber, and Guided-Wave Optics
- Applications Engineering
- Design, Fabrication and Evaluation
- Critical Analysis of Technology
- Troubleshooting
- Marketing

R.A. Becker, D. Sc.
President
(408) 446-9812
10482 Chisholm Ave.
Cupertino, CA 95014

Patent Attorney

Electronics – Signal Processing

I. Ionescu, MSEE, PE, JD
Patent Office Reg # 33185
203-381-9400
Box 697, Stratford, CT 06497

T-TECHTM
1 DEAN STREET/BOX 151
HUDSON, MASSACHUSETTS
VOICE: (508) 562 5820
FAX: (508) 568 1219

RF/ANALOG/VIDEO/FIBEROPTICS/ASIC'S
THE CORRECT, AFFORDABLE, AND TIMELY SOLUTION TO:
- FREQ. SYNTHESIS (CONSUMER, BROADCAST, INDUSTRIAL, MIL)
- FIBEROPTICS (LAN'S, VIDEO, AUDIO, DATA, CATV)
- CATV EQUIPMENT DESIGN
- RF TO 2 GHZ: FILTERS, EQUALIZERS, SYSTEMS, CIRCUITS, PLL's
- PROTOTYPING, LAB, R & D, AND CAE FACILITIES
- THIN/THICK FILM HYBRIDS OR ASIC'S (ANALOG OR MIXED)

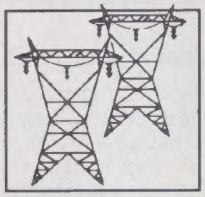
Complete Service for Lightning Protection, Grounding and Power Conditioning

We Guarantee NO Strikes

Call Lightning Eliminators & Consultant, Inc.
6687 Arapahoe Road
Boulder, Colorado 80303
(303) 447-2828
FAX (303) 447-8122

Power Systems Analysts

Come grow with us ... dynamic expansion creates exciting career opportunities



Harris Corporation, with sales of over $3 billion, is a producer of state-of-the-art information processing, office automation, communication and microelectronic products for the worldwide information technology market. Harris' Controls and Composition Division, located in **Melbourne, Florida**, is experiencing continued growth creating additional positions in which you can combine fast-paced, sophisticated technology with the warm and relaxed lifestyle of Florida's Space Coast.

For more than half a century, we have been involved in the evolution of Supervisory Control and Data Acquisition (SCADA) systems. Today, as an industry leader, we provide large scale energy management systems for electric utilities including full graphics applications and relational data interface in an open architecture. Due to our dynamic growth, we are currently seeking Power Systems Analysts.

You will be responsible for designing and implementing state-of-the-art software in the areas of state estimation, security analysis, resource management, unit commitment and optimal power flow. To qualify, you should possess a BS, MS or PhD degree in Electrical Engineering plus a solid background in power systems analysis and FORTRAN or "C" programming.

If you would like to know more about these exciting opportunities for personal and professional growth and advancement awaiting you at Harris, please call Lisa Dolan COLLECT at (407) 242-4048. Or forward your resume, including salary history, to her attention at Harris Controls and Composition Division, P.O. Box 430, Melbourne, Florida 32902. We are an equal opportunity employer M/F/H/V.

HARRIS

UNIVERSITY OF BRITISH COLUMBIA
ADVANCED TECHNOLOGY MANAGEMENT PROGRAM

Faculty of Applied Science

The Faculty of Applied Science invites application for a tenure track position in engineering at either the Assistant or Associate Professor level. The position will be in support of the new Master of Engineering Program in Advanced Technology Management to be offered jointly with the Faculty of Commerce and Business Administration. Appointment will be effective either July 1, 1991 or January 1, 1992.

Candidates for the position should hold a Ph.D. in an engineering discipline. A superior research record, a desire to work with graduate students and the ability to teach at the undergraduate level are additional requirements. Research interests may be based in any of the major fields of engineering. Candidates must have relevant technology management experience.

Applications should be made to:
Dr. Axel Meisen
Dean, Faculty of Applied Science
The University of British Columbia
2324 Main Mall
Vancouver, B.C. V6T 1W5

Faculty of Commerce and Business Administration

The Faculty of Commerce and Business Administration invites application for a tenure-track position at the Associate Professor level. The position will be in support of a new master's program in the area of Advanced Technology Management to be offered jointly with the Faculty of Applied Science. Appointment will be effective either July 1, 1991 or January 1, 1992.

Candidates for the position should hold an undergraduate degree in engineering and a Ph.D. in an area of business administration. A superior research record, experience in working with graduate students and the ability to teach at the undergraduate level are additional requirements. Research interests may be based in any of the major fields of business administration.

Applications should be made to:
Dr. Peter Lusztig
Dean, Faculty of Commerce and Business Administration
The University of British Columbia
2053 Main Mall
Vancouver, B.C. V6T 1Y8

The University of British Columbia is committed to the Federal Government's employment equity program and encourages applications from all qualified individuals.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents.

SCANNING THE INSTITUTE

Merrill W. Buckley Jr. is 1991 President-Elect

The 1990 general election tally gave the office of President-Elect to Merrill W. Buckley Jr. Runners-up in order of votes received were Martha Sloan, Edward C. Bertnolli, Theodore W. Hissey Jr., and Edward A. Parrish.

Other elected officers were: Region 2 Director, Charles K. Alexander Jr.; Region 4 Director, Howard L. Wolfman; Region 6 Director, Jerry C. Aukland; Division II Director, Lloyd A. Morley; Division IV Director, Martin V. Schneider; Division VI Director, V. Thomas Rhyne; Division VIII Director, Helen M. Wood; Division X Director, H. Vincent Poor; Region 5 Director-Elect, James V. Leonard; Region 7 Director-Elect, Vijay R. Bhargava; Region 2 Vice Chairman, Arthur Van Gelder; and Region 6 Vice Chairman, Chester C. Taylor. Director J. Thomas Cain was confirmed as Regional Director to the IEEE Assembly. [THE INSTITUTE, December, p. 8]

Advanced synchrotron in Europe

Under construction since January, Europe's first dedicated synchrotron radiation facility, in Grenoble, France, will have a permanent staff of 430 persons.

Funded at 2.2 billion French francs (US $400 million) by its member nations—France, Germany, Italy, the United Kingdom, Spain, Switzerland, Belgium, Holland, Sweden, Denmark, Norway, and Finland—the synchrotron will be used in such areas as characterizing the submicrometer structure of high-density integrated circuits; characterizing high-temperature superconductors; and studying the crystal lattice structure surrounding doping impurities in semiconductors. [THE INSTITUTE, December, p. 1]

Emerson spins off defense units

Emerson Electric Co. and Hazeltine Corp. went their separate ways in October. Their marriage began four years ago, when Emerson, of St. Louis, Mo., bought Hazeltine, Greenlawn, N.Y., for US $189 million.

According to Emerson spokesperson James Orso, the breakup was due not to defense industry woes, but to Emerson's desire to focus on its faster-growing and more profitable commercial businesses.

Hazeltine, four other former Emerson defense subsidiaries, and an Emerson commercial subsidiary were spun off as a separate, independent company, EXCO Electronics Corp., based in St. Louis. [THE INSTITUTE, December, p. 1]

Sections Congress sets priorities

Delegates to the Regional Activities Board's Sections Congress in Toronto in October prioritized 26 recommended actions. The 650 delegates selected as the top priority the development of plans for enhancing corporate support of employee involvement in the IEEE, emphasizing the value of membership to the employer.

At the adjournment of the Congress, Robert T.H. Alden, Vice President–Regional Activities, called a meeting at which an inter-entity task assignment committee met to assign the recommended actions to the various IEEE boards. [THE INSTITUTE, December, p. 8]

Japan braces for the big quake

About 10 Japanese construction companies are currently researching earthquake technology. Historically, a major earthquake has occurred about once every 60 years in Japan. The last one killed about 140 000 people in Tokyo in 1923.

The companies are researching isolation systems, constructed under a building to keep it from directly touching the ground, and the use of sensors and computers that can detect, and in some cases intelligently counteract, earthquake motions. [THE INSTITUTE, December, p. 1]

COMING IN SPECTRUM

"Technology '91," *IEEE Spectrum*'s annual overview of existing hardware and software, will be published in January. It will spotlight the major trends and advances in the fields covered by the magazine throughout the year.

Technical areas to be reviewed are personal computers, workstations, microcomputers, system software, design tools, minis, mainframes, supercomputers, telecommunications, data communications, solid state, instrumentation, industrial electronics, power and energy, consumer electronics, transportation, aerospace and military, and medical electronics.

Each article will open with a brief discussion of the burning issue or issues and the most significant development in that field by a recognized expert. The body of each article, written by a *Spectrum* editor, will detail the major developments in the field during the previous year noted in terms of both hardware and software available.

Experts for the issue and their areas are: Eric E. Schmidt, Sun Microsystems Inc., PCs/ workstations/ micros; Eric Wagner, Ithaca Software, system software/design tools; Brad M. Friedlander, Arthur D. Little Inc., minis/mainframes, supers; Laurence B. Milstein, University of California at San Diego, telecommunications; Dipankar Raychaudhuri, David Sarnoff Research Center, data communications; Shorjiro Asai, Hitachi Ltd., solid state; Richard D. Thornton, Massachusetts Institute of Technology, instrumentation; Ren-Ghyuan Luo, North Carolina State University, industrial electronics; Henri Persoz, Electricité de France, power and energy; Wayne C. Luplow, Zenith Electronics Corp., consumer electronics; Anthony R. Eastham, Queen's University, Kingston, Ont., transportation; Robert S. Cooper, Atlantic Aerospace Electronics Corp., aerospace and military; and Charles J. Robinson, Hines VA Hospital, medical electronics.

ADVERTISING SALES OFFICES

345 East 47th Street, New York, N.Y. 10017

William R. Saunders	Advertising Director	705-7767
Richard B. Ofstie	Eastern Advertising Manager	705-7311
Eugene V. Lombardo	New York Manager	705-7312
Hendrik Prins	Research Manager	705-7067
Joanne Biley	Circulation and Research Administrator	705-7067
Wendy I. Goldstein	Advertising Production Manager	705-7579

Boston, Mass.–Gerard S. Mullin, Doug Long, The Channel, Brewster, 02631 508-896-5930

Philadelphia, Pa.–Daniel P. Mainieri Jr., 650 N. Cannon Ave. #13, Lansdale, 19446 215-368-8232

Chicago, Ill.–Ralph Bergen, 540 Frontage Road, Northfield, 60093 708-446-1444

San Francisco, Calif.–Denis F. Duffy, 33 New Montgomery, Suite 980, 94105 415-541-0377

Los Angeles, Calif.–Lynne Andrew Evans, 5777 West Century Boulevard, #635, 90045 213-649-3800

Atlanta, Ga.–H. Michael Coleman, C. William Bentz III 4651 Roswell Road N.E., 30342 404-256-3800

Dallas, Texas–Stephen D. Gillett, 14114 Dallas Parkway, Suite 245, 75240 214-788-2939

Tokyo, Japan–German Tajiri IMI Corp., Saito Lend Bldg., 13-5, Ginza 3-chome, Chuo-ku, Tokyo 104. (03) 546-2231. TELEX: J23449 (IMI TOKYO)

London, England–Ric Bessford, 5 High St., Windsor, Berks SL4 1LD, 75-383-1238

Publisher: Donald Christiansen
Administrative Assistant: Nancy T. Hantman
Associate Publisher: William R. Saunders (Advertising)
Administrative Assistant: Eric Sonntag
Vice President, Publications: Ralph W. Wyndrum Jr.

ADVERTISERS INDEX

Circle numbers on the Reader Service Card, opposite page 96, that correspond to the advertisers listed below

RS#	Advertiser	Page #
5	CSPI	17
2	Data Delay Devices	25
24	Hewlett-Packard Calculators	28H
4	Hyperception	cover 2
40	INSPEC	28E
27	Intusoft	28F
32	Jandel Scientific	28D
33	Jandel Scientific	80
7	MacNeal-Schwendler	26
6	Mathsoft	27
26	Mathworks	28A
10	Maxwell Labs	12
20	Mitchell & Gauthier Associates	28B
1	Mita Press	13
22	Momentum Data Systems	28F
8	National Instruments	24
25	Netherland Foreign Investment Agency	28C
3	Omega	1
30	Pemberly Kent Publishing	28E
11	RLM Research	8
23	Systems Control Technology	30
9	Teledyne Solid State	7
21	3D Visions	25
31	TriMetrix	23
29	University of Idaho	28E
28	University of Massachusetts Video Instruction Program	28F

He knows the difference between a Nyquist curve and a demand curve.

Today's highly charged, high-tech corporate environment demands bilingual management, as fluent in the language of the laboratory as in the idioms of the boardroom.

Terrence McGarty, Corporate Director, Applied Research at NYNEX is just such a manager. Among his three MIT degrees is a PhD in Electrical Engineering. In addition to charting the course for the Applied Research Laboratories at the NYNEX Science & Technology Center, he manages the corporate venture capital funds and has authored a recently published book on business planning for entrepreneurs.

As the head of an organization committed to developing and delivering cutting edge technology that is as easy to use as the telephone, McGarty needs a magazine that goes beyond surface coverage.

He is one of 500,000 scientific/engineering professionals who read SPECTRUM magazine to gain useful insight into emerging state-of-the art technologies that will direct their roles in shaping our tomorrows.

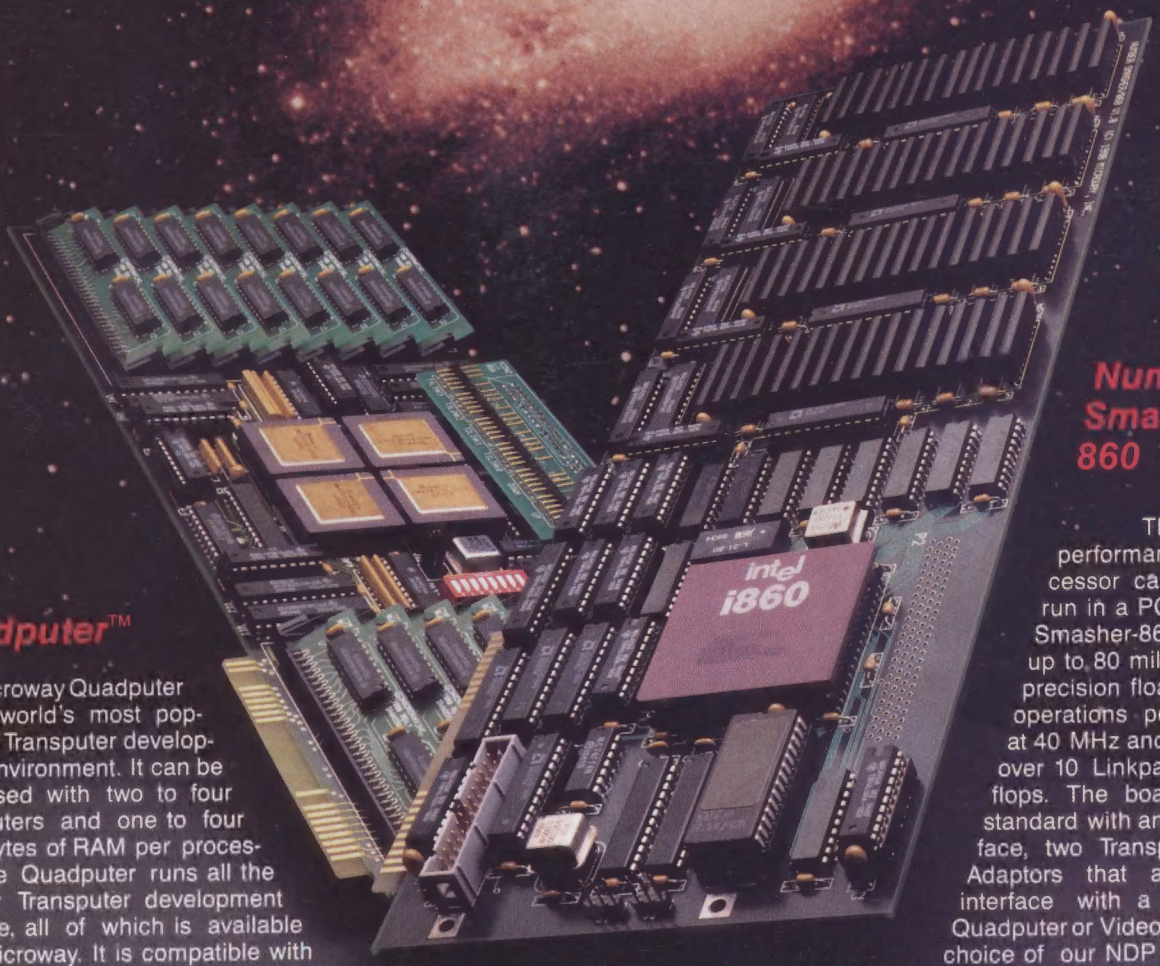
SPECTRUM—essential, relevant, informative. Reaching readers who create tomorrow, today.

IEEE SPECTRUM
MAGAZINE

345 East 47th Street, New York, NY 10017, U.S.A. · 212-705-7760

Spectrum is published by The Institute of Electrical and Electronics Engineers, Inc.

Discover Parallel Processing



Quadputer™

The Microway Quadputer is the world's most popular PC Transputer development environment. It can be purchased with two to four Transputers and one to four megabytes of RAM per processor. The Quadputer runs all the popular Transputer development software, all of which is available from Microway. It is compatible with our Monoputer™ which provides 1 to 16 megabytes of RAM and a single T800, our Videoputer™ which comes in VGA and higher resolution versions and is powered by a memory mapped pair (T800 and 34010), and our Linkputer™ whose cross bar switching network can dynamically link up to 32 Transputers. Finally, all Microway Transputer products can be used with our Number Smasher-860 to provide out-of-this-world numeric performance!

For more information, please call 508-746-7341.

Number Smasher® 860

The highest performance coprocessor card to ever run in a PC, Number Smasher-860 delivers up to 80 million single precision floating point operations per second at 40 MHz and produces over 10 Linkpack megaflops. The board comes standard with an ISA interface, two Transputer Link Adaptors that allow it to interface with a Microway Quadputer or Videoputer, your choice of our NDP Fortran, C or Pascal for the 80860, plus 8 megabytes of high speed memory.

NDP Fortran-860, C-860 and C++860

Microway NDP 860 Compilers make it easy to recompile your favorite mainframe, 80386 or PC applicaton for the 80860. The resulting code runs on our XTEND-860™ environment under DOS, UNIX or XENIX.

Microway

The World Leader in PC Numerics

Corporate Headquarters, Research Park, Box 79, Kingston, MA 02364
TEL 508-746-7341 • FAX 508-746-4678
U.K. - 32 High St., Kingston-Upon-Thames, 081-541-5466 • Italy 02-74.90.749
Holland 40 836455 • Germany 069-75-2023 • Japan 81 3 222 0544

Circle No. 41